

(12) United States Patent

Uchida et al.

US 9,329,369 B2 (10) **Patent No.:** (45) **Date of Patent:**

May 3, 2016

(54) OPTICAL SYSTEM AND OPTICAL INSTRUMENT, IMAGE PICKUP APPARATUS, AND IMAGE PICKUP SYSTEM USING THE **SAME**

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(JP)

Subject to any disclaimer, the term of this patent is extended or adjusted under 35

U.S.C. 154(b) by 0 days.

(21) Appl. No.: 14/830,283

(*) Notice:

Aug. 19, 2015 (22)Filed:

(65)**Prior Publication Data**

Dec. 10, 2015 US 2015/0355445 A1

Related U.S. Application Data

(60) Division of application No. 14/529,885, filed on Oct. 31, 2014, now Pat. No. 9,151,937, which is a continuation of application No. PCT/JP2013/075153, filed on Sep. 18, 2013.

(30)Foreign Application Priority Data

Sep. 21, 2012 (JP) 2012-208980

(51) Int. Cl.

G02B 15/14 (2006.01)G02B 5/00 (2006.01)

(Continued)

(52) U.S. Cl.

CPC G02B 15/14 (2013.01); G02B 5/005 (2013.01); G02B 13/18 (2013.01); G02B 13/26 (2013.01); G02B 21/02 (2013.01); G02B 21/06 (2013.01); G02B 21/26 (2013.01)

(58) Field of Classification Search

CPC G02B 15/14; G02B 13/003; G02B 13/12; G02B 7/282 USPC 359/642–830

See application file for complete search history.

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8.564.756 1	B2	10/2013	Kuba

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Primary Examiner — Mahidere Sahle

(74) Attorney, Agent, or Firm — Kenyon & Kenyon LLP

ABSTRACT (57)

An optical system which forms an optical image on an image pickup element, comprising in order from an object side,

- a first lens unit having a positive refractive power, which includes a plurality of lenses,
- a stop, and
- a second lens unit which includes a plurality of lenses, wherein
- the first lens unit includes a first object-side lens which is disposed nearest to an object, and
- the second lens unit includes a second image-side lens which is disposed nearest to an image, and
- the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

the following conditional expressions are satisfied:

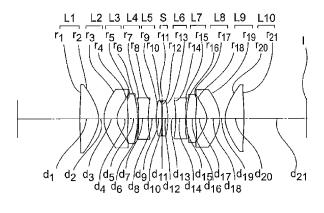
β≤-1.1 (15)

0.08<NA (16)

1.0<WD/BF (19)

 $0.5 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 4.0$ (20).

35 Claims, 107 Drawing Sheets



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JP JP	2005-049711 A 2008-185965	2/2005 8/2008		onal Search Report, dated national Application No.				

FIG. 1

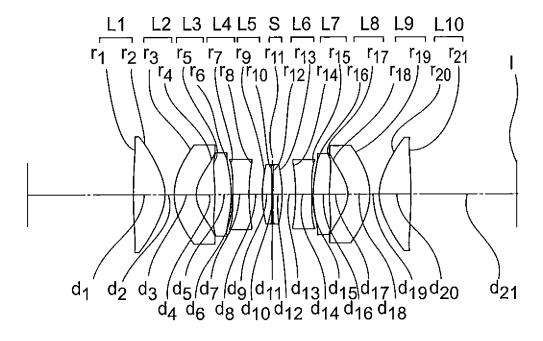


FIG. 2A

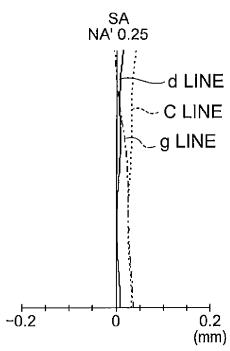


FIG. 2B

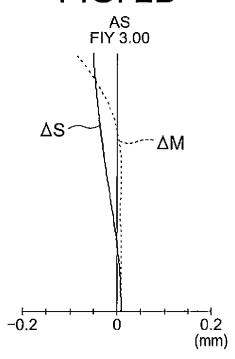


FIG. 2C

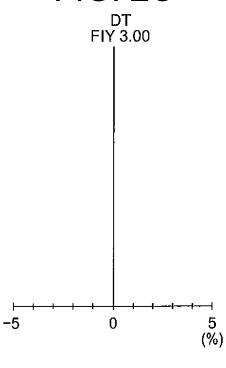


FIG. 2D

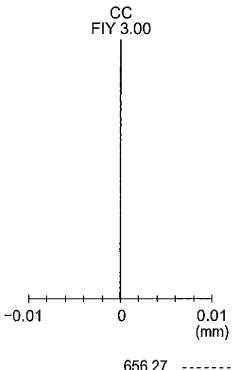
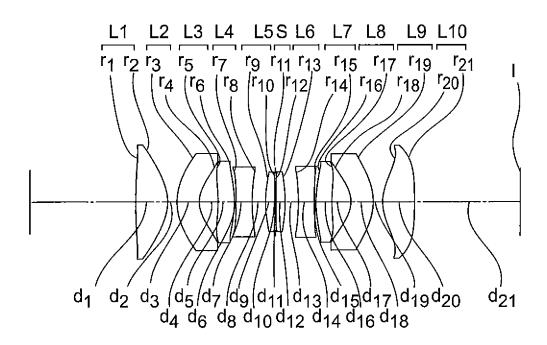


FIG. 3



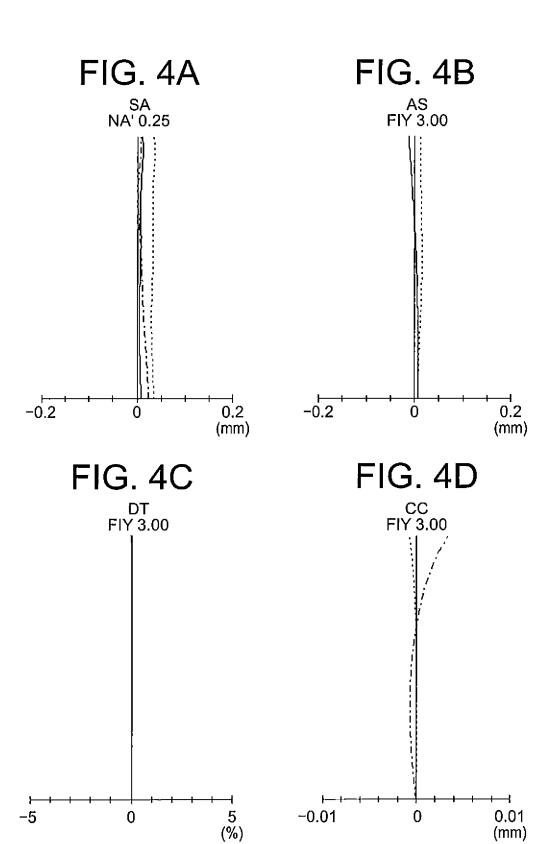
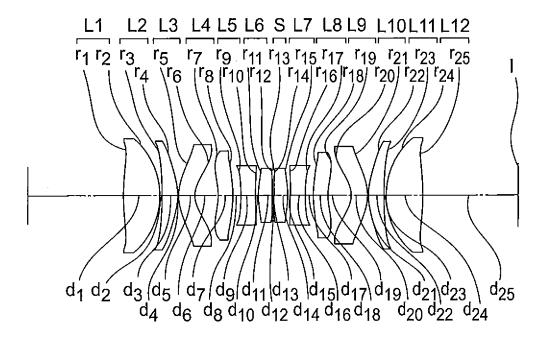


FIG. 5





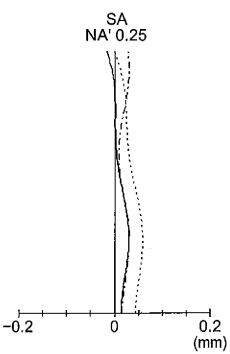


FIG. 6B

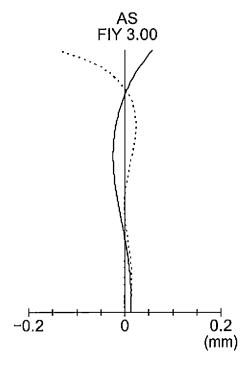


FIG. 6C

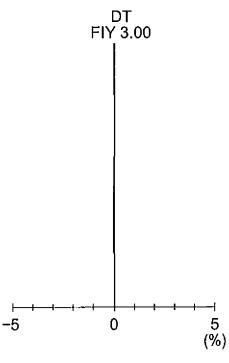


FIG. 6D

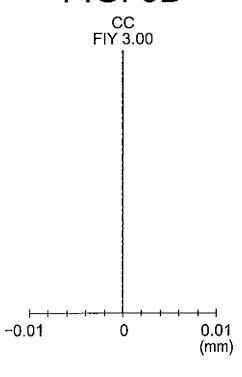
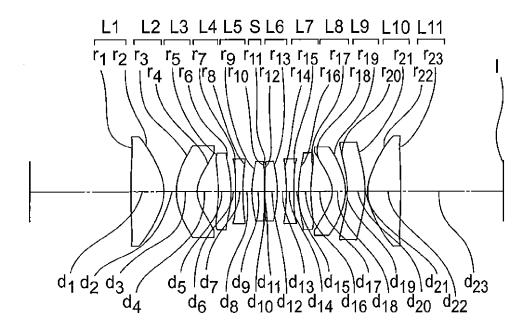


FIG. 7



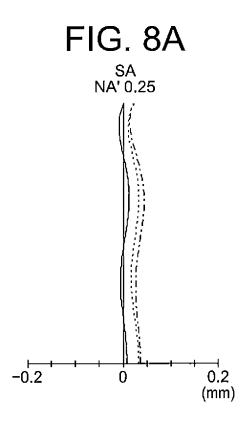


FIG. 8B

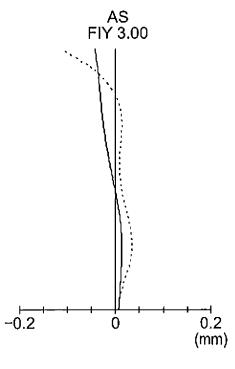


FIG. 8C

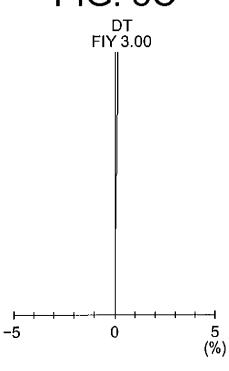


FIG. 8D

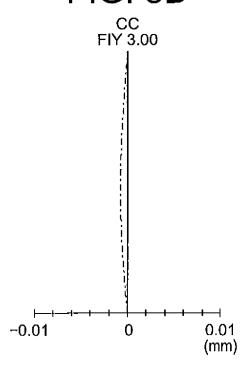
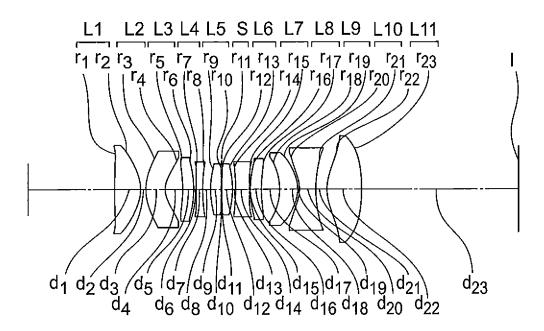


FIG. 9



-0.2



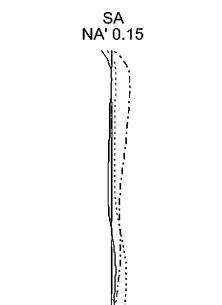


FIG. 10B

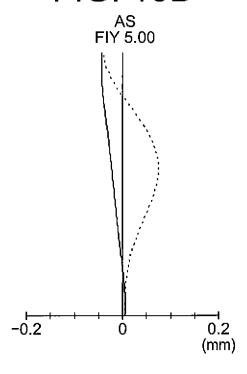


FIG. 10C

Ò

0.2 (mm)

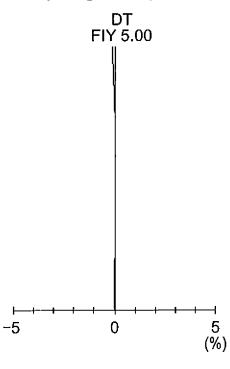


FIG. 10D

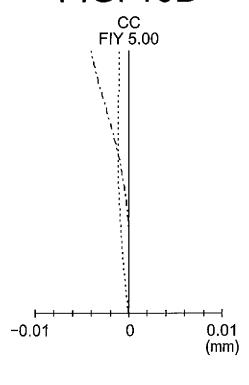
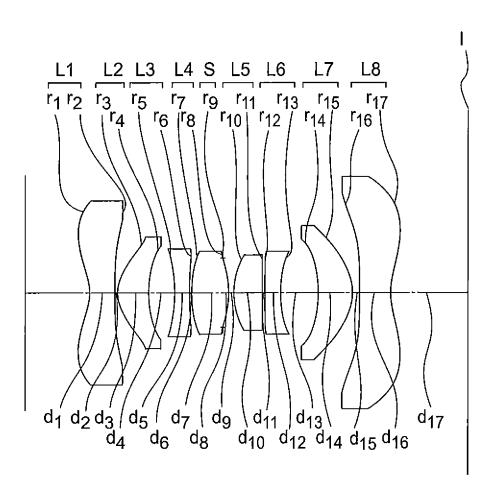


FIG. 11



-0.2

FIG. 12A

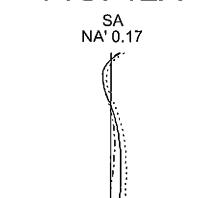


FIG. 12B

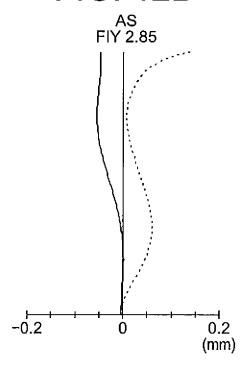


FIG. 12C

0.2

(mm)

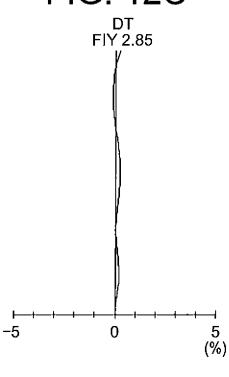


FIG. 12D

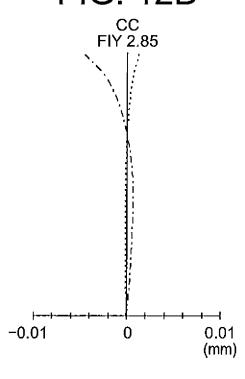
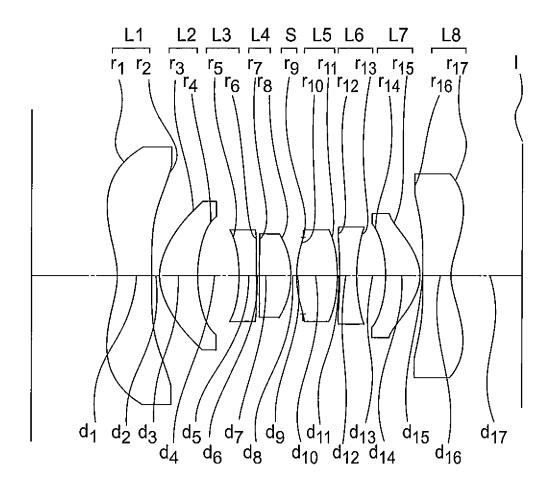


FIG. 13





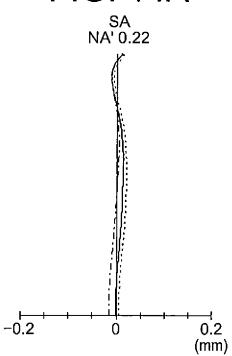


FIG. 14B

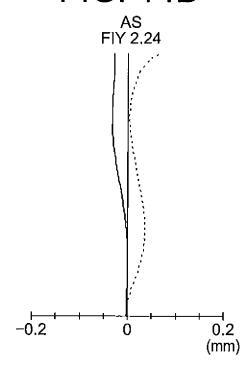


FIG. 14C

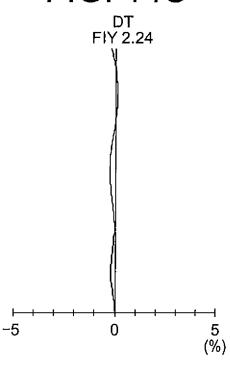


FIG. 14D

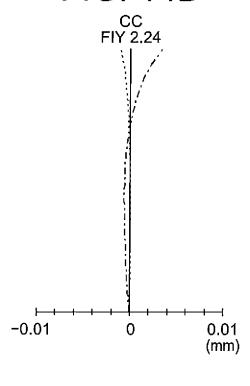


FIG. 15A

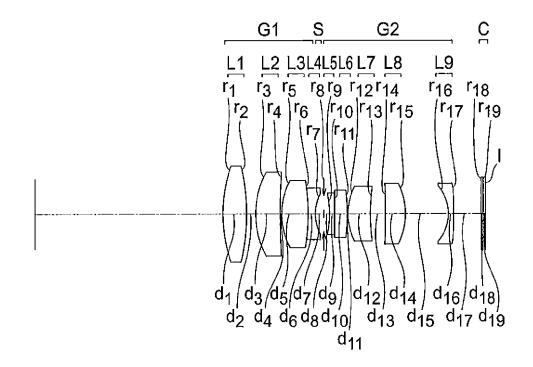


FIG.15B FIG.15C FIG.15D FIG.15E

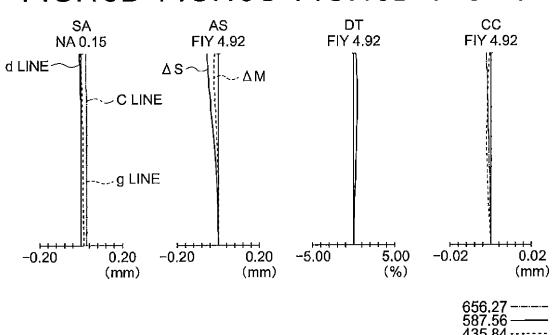


FIG. 16A

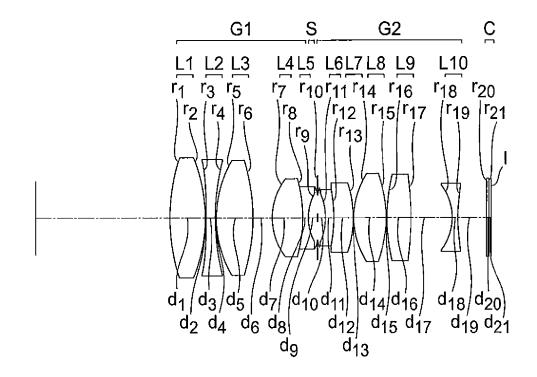


FIG.16B FIG.16C FIG.16D FIG.16E

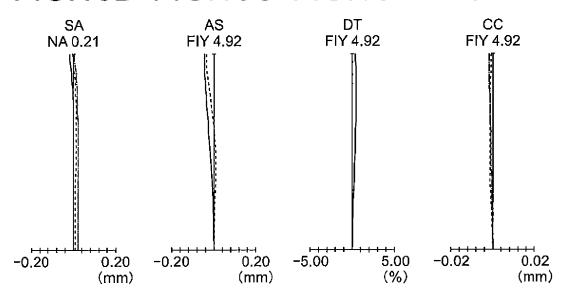


FIG. 17A

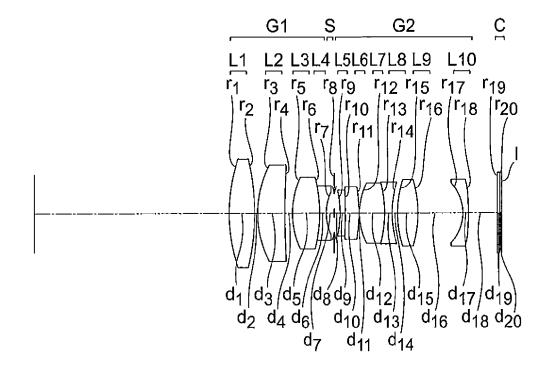


FIG.17B FIG.17C FIG.17D FIG.17E

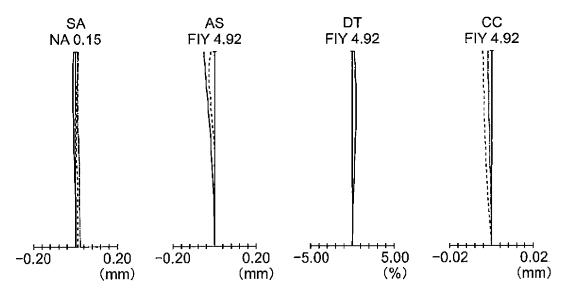


FIG. 18A

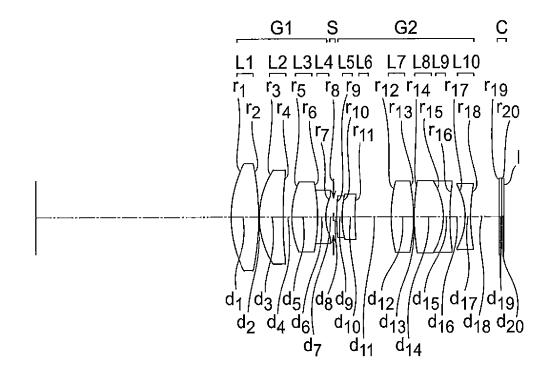


FIG.18B FIG.18C FIG.18D FIG.18E

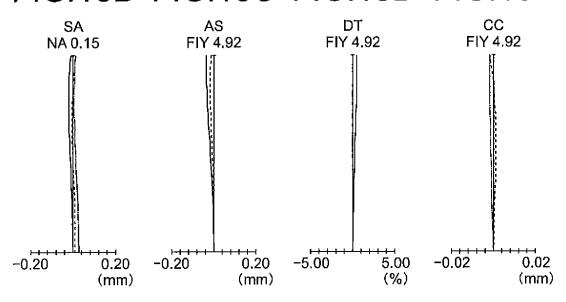


FIG. 19A

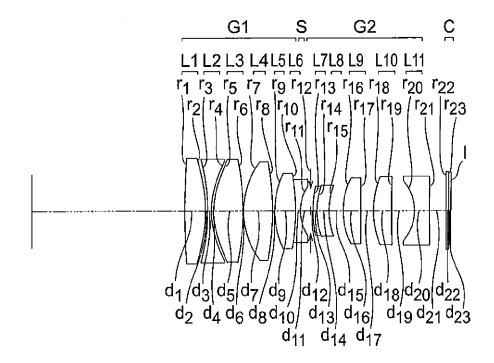


FIG.19B FIG.19C FIG.19D FIG.19E

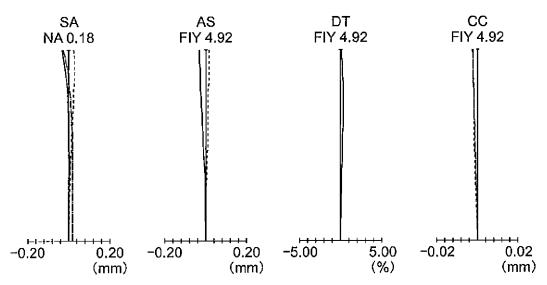


FIG. 20A

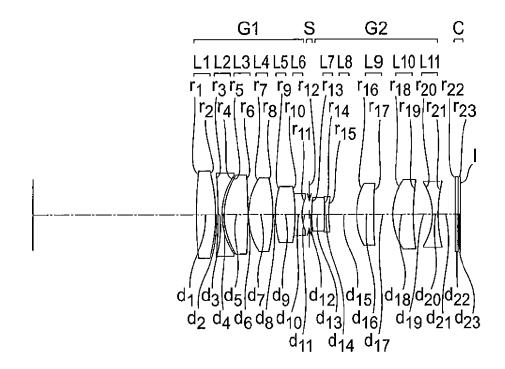


FIG.20B FIG.20C FIG.20D FIG.20E

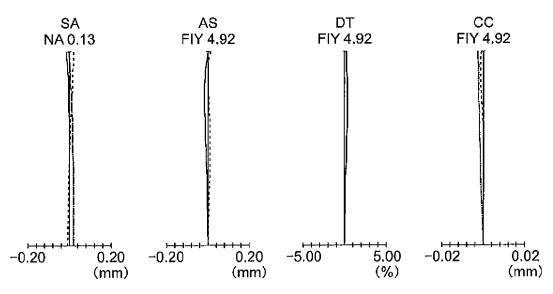


FIG. 21A

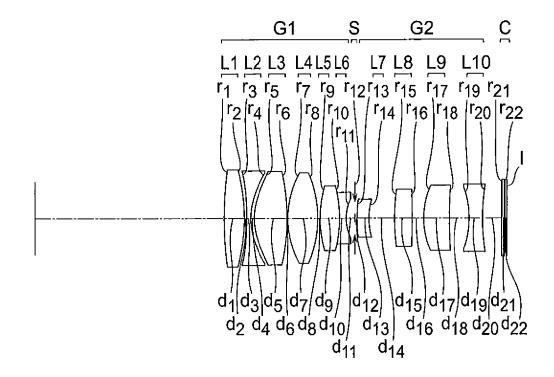


FIG.21B FIG.21C FIG.21D FIG.21E

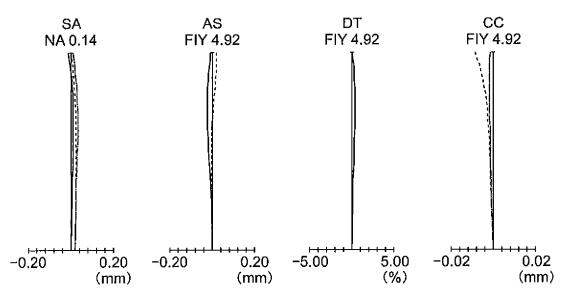


FIG. 22A

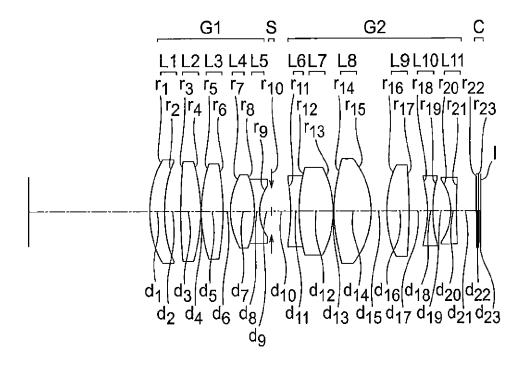


FIG.22B FIG.22C FIG.22D FIG.22E

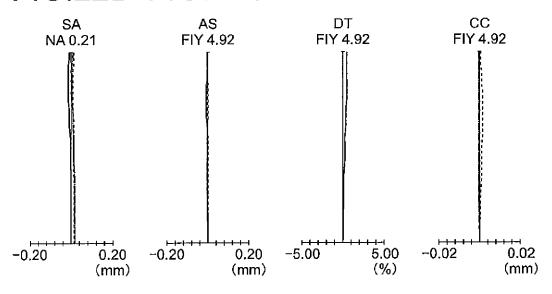


FIG. 23A

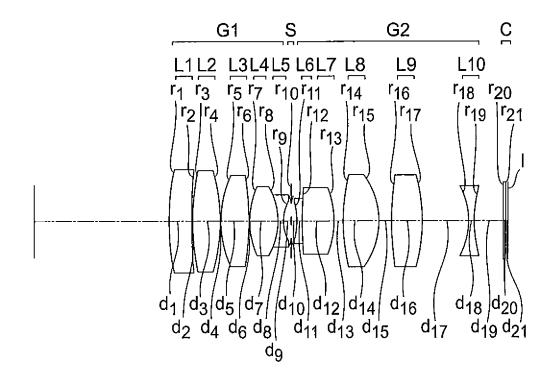


FIG.23B FIG.23C FIG.23D FIG.23E

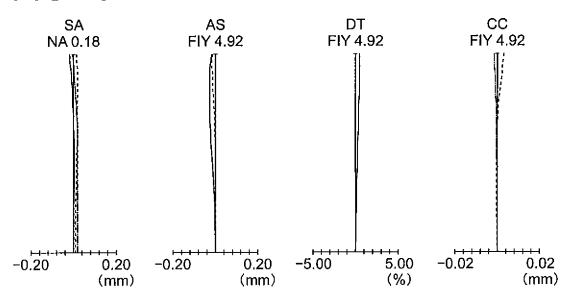


FIG. 24A

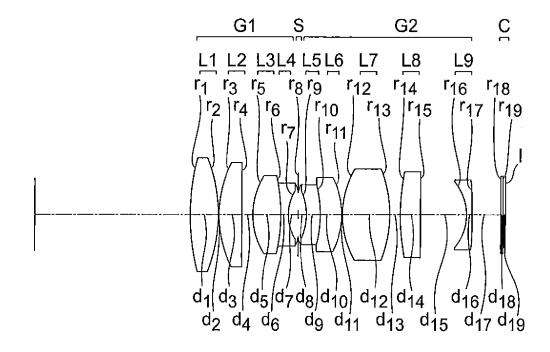


FIG.24B FIG.24C FIG.24D FIG.24E

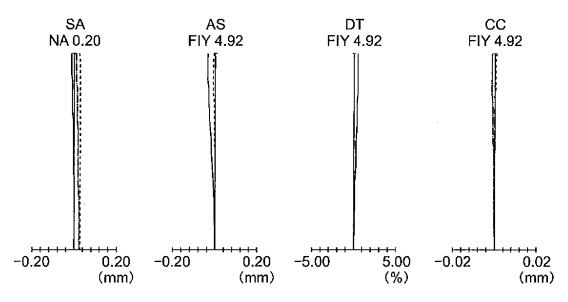


FIG. 25A

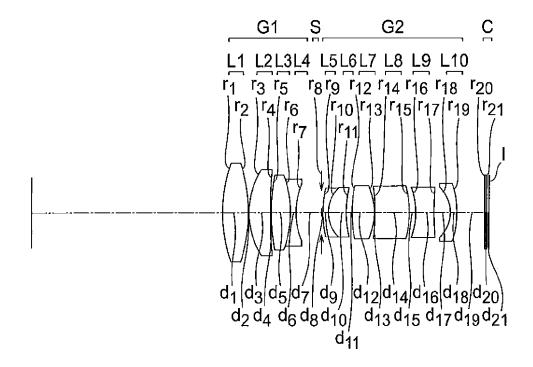


FIG.25B FIG.25C FIG.25D FIG.25E

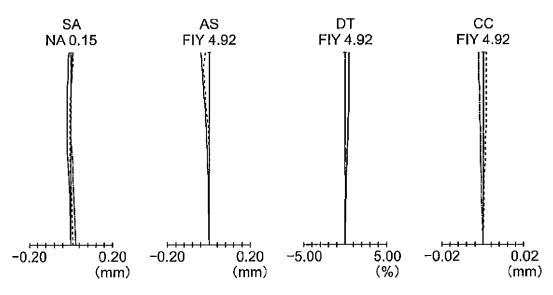


FIG. 26A

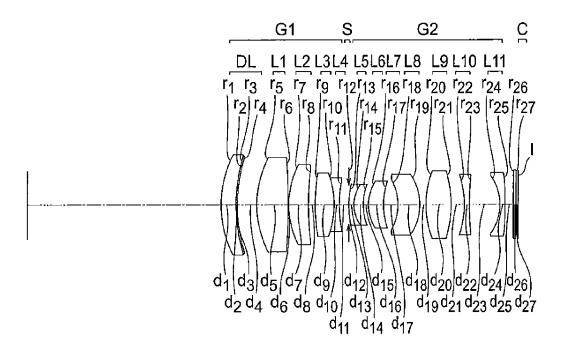


FIG.26B FIG.26C FIG.26D FIG.26E

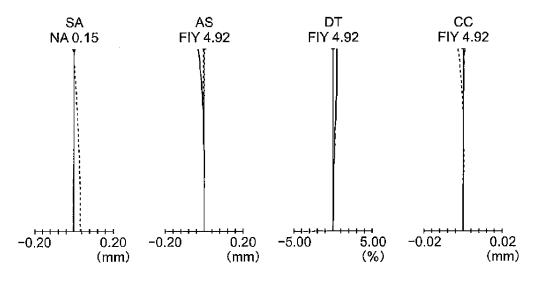


FIG. 27A

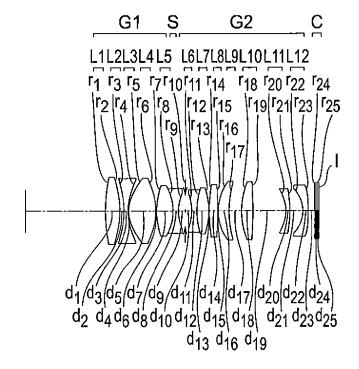


FIG.27B FIG.27C FIG.27D FIG.27E

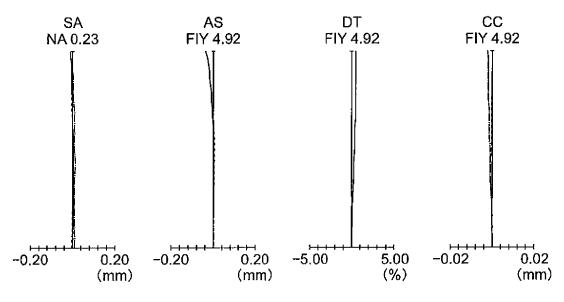


FIG. 28A

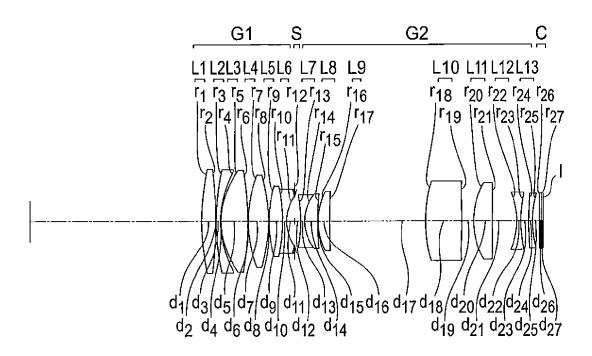


FIG.28B FIG.28C FIG.28D FIG.28E

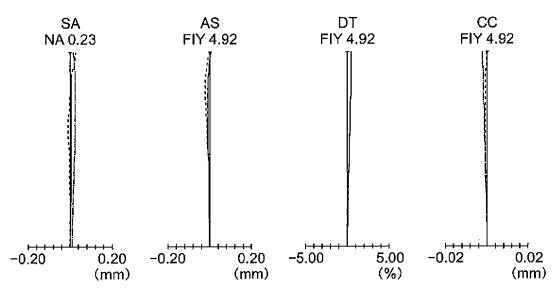


FIG. 29A

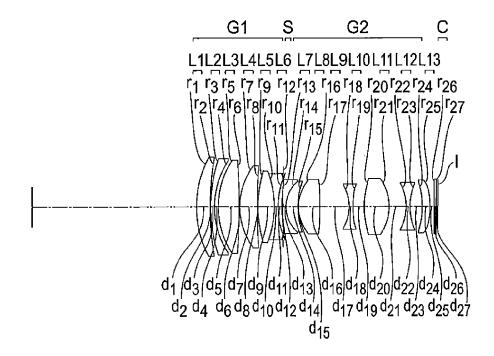


FIG.29B FIG.29C FIG.29D FIG.29E

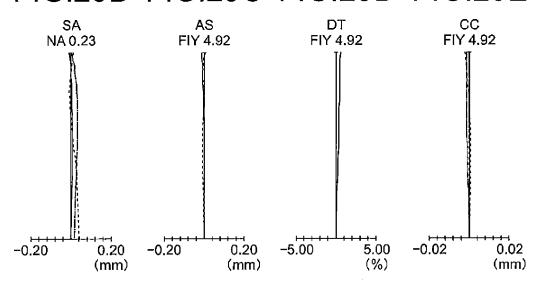


FIG. 30A

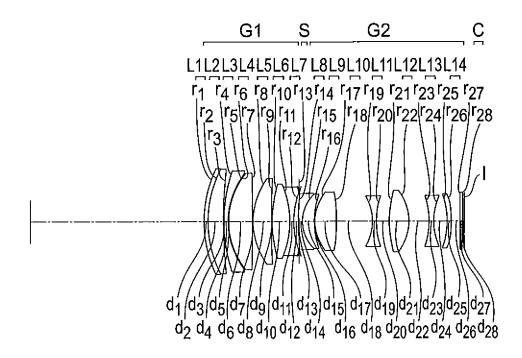


FIG.30B FIG.30C FIG.30D FIG.30E

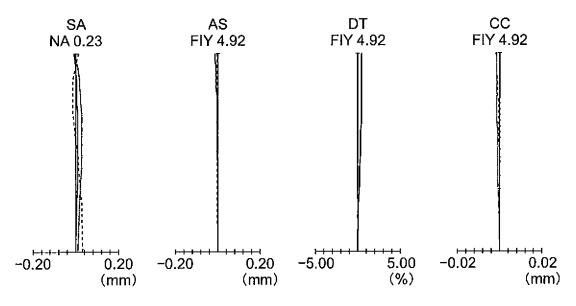


FIG. 31A

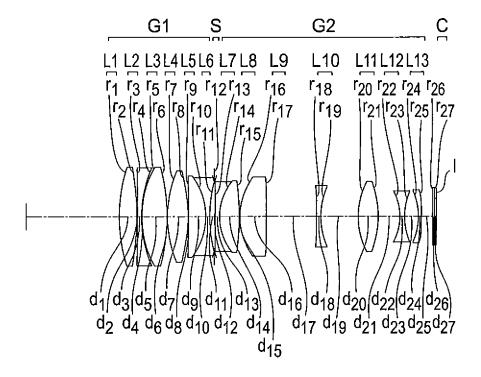


FIG.31B FIG.31C FIG.31D FIG.31E

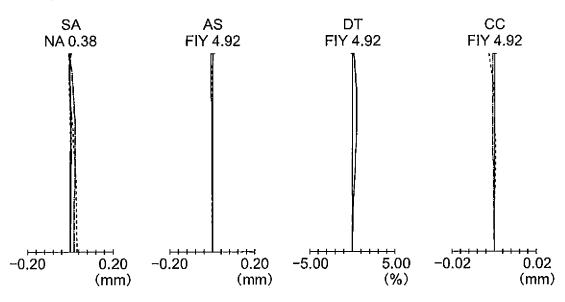


FIG. 32A

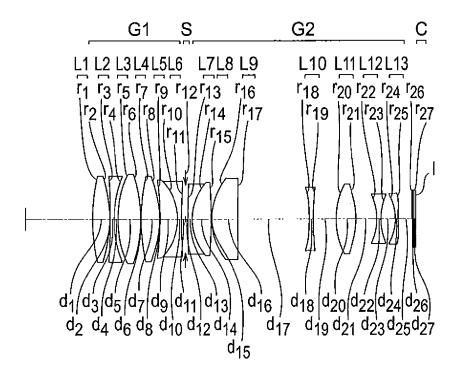


FIG.32B FIG.32C FIG.32D FIG.32E

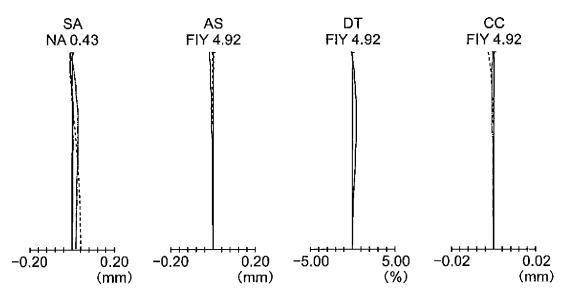


FIG. 33A

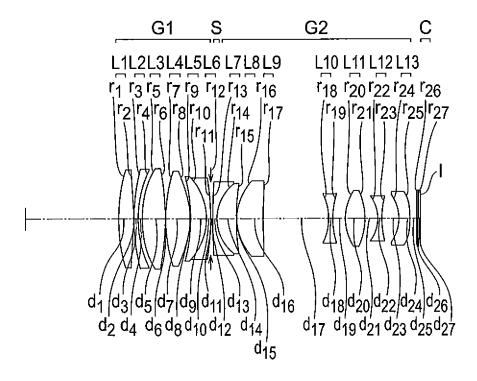


FIG.33B FIG.33C FIG.33D FIG.33E

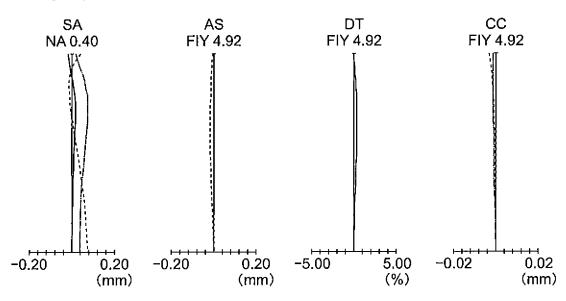


FIG. 34A

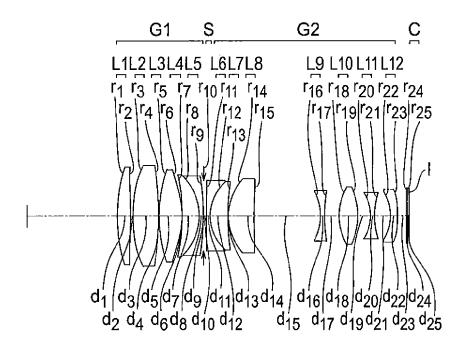


FIG.34B FIG.34C FIG.34D FIG.34E

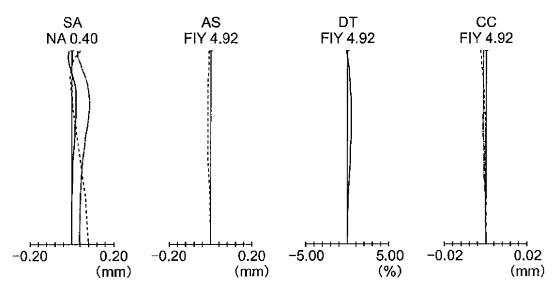


FIG. 35A

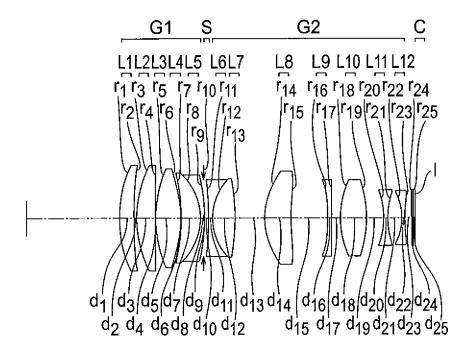


FIG.35B FIG.35C FIG.35D FIG.35E

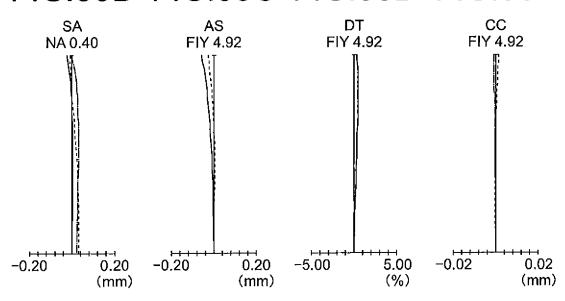


FIG. 36A

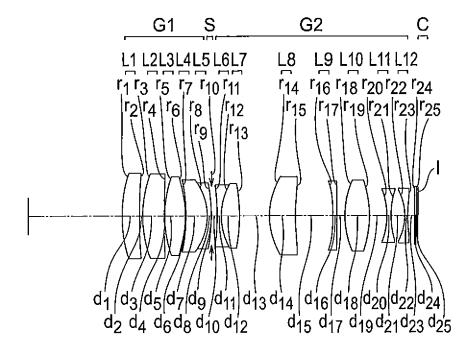


FIG.36B FIG.36C FIG.36D FIG.36E

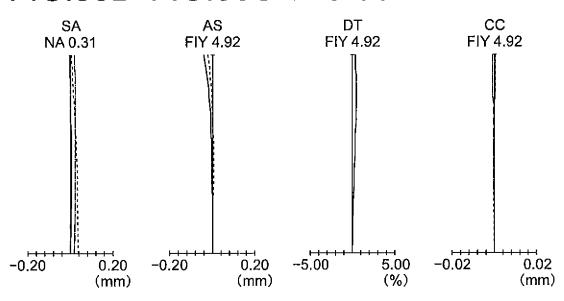


FIG. 37A

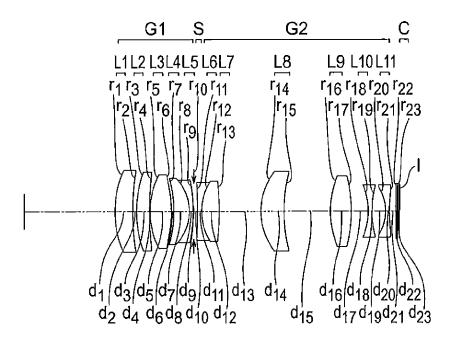


FIG.37B FIG.37C FIG.37D FIG.37E

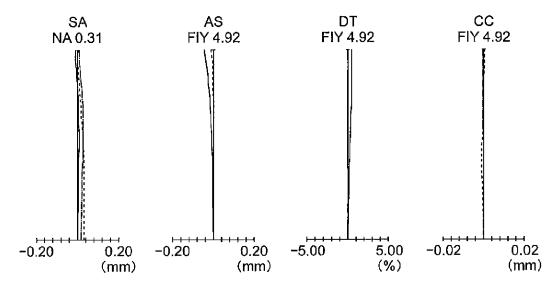


FIG. 38A

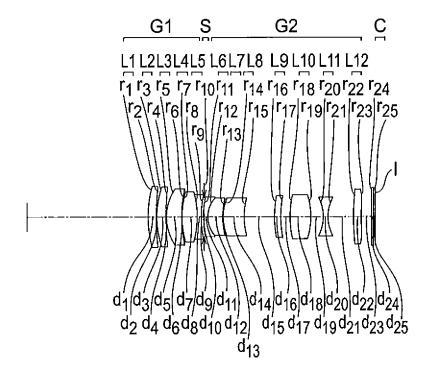


FIG.38B FIG.38C FIG.38D FIG.38E

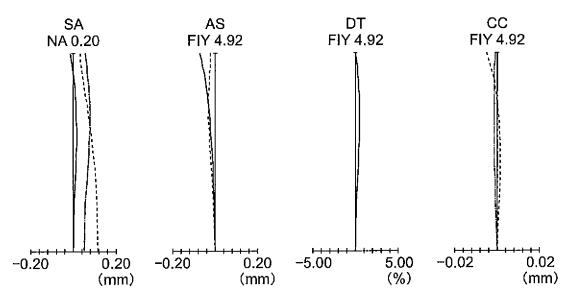


FIG. 39A

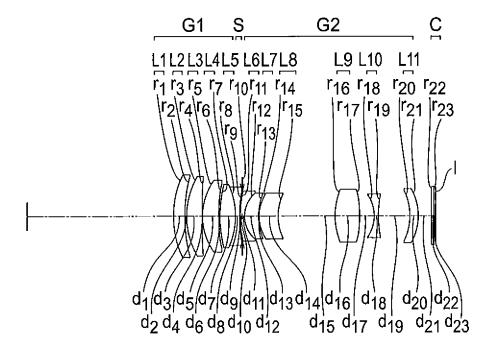


FIG.39B FIG.39C FIG.39D FIG.39E

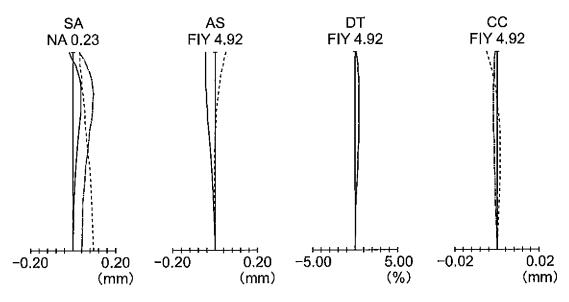


FIG. 40A

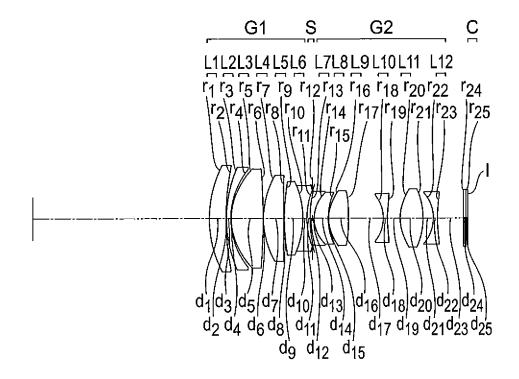


FIG.40B FIG.40C FIG.40D FIG.40E

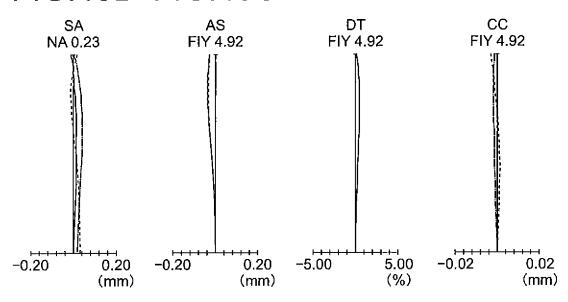


FIG. 41A

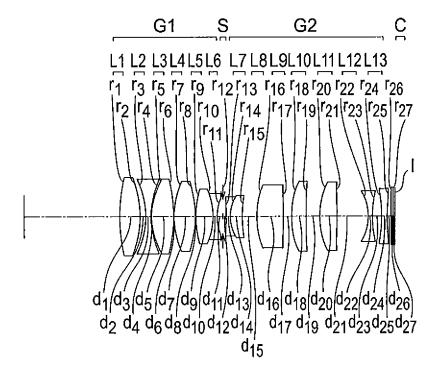


FIG.41B FIG.41C FIG.41D FIG.41E

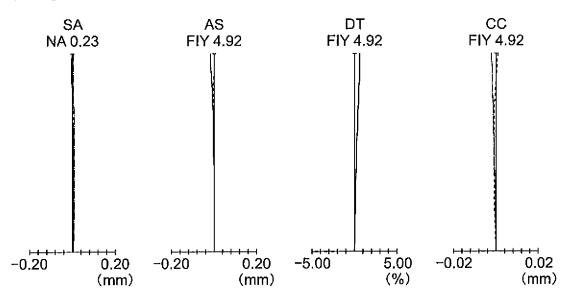


FIG. 42A

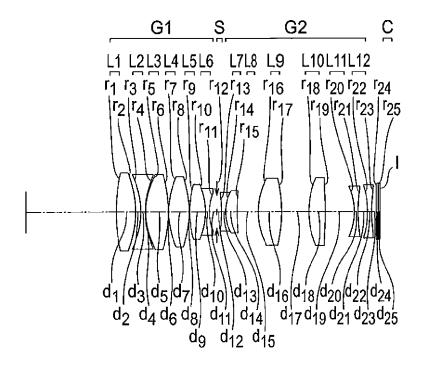


FIG.42B FIG.42C FIG.42D FIG.42E

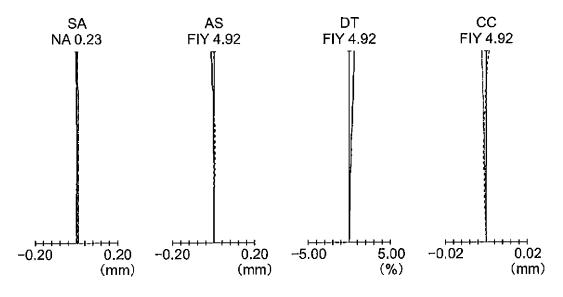


FIG. 43A

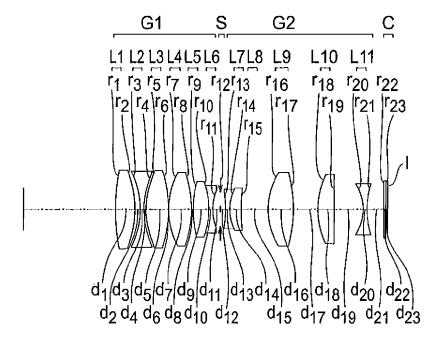


FIG.43B FIG.43C FIG.43D FIG.43E

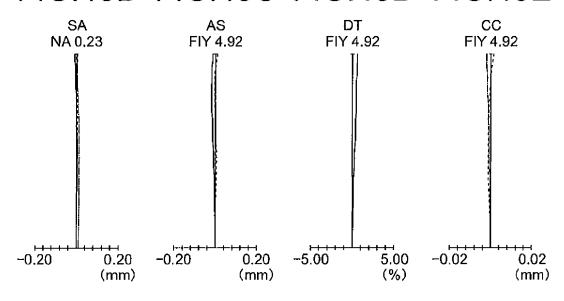


FIG. 44A

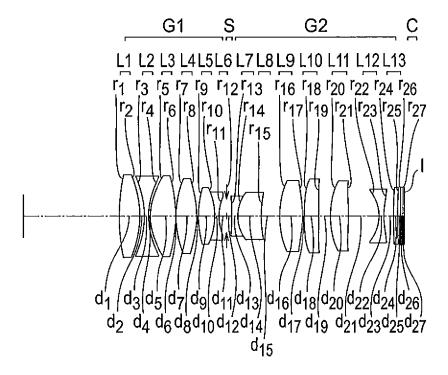


FIG.44B FIG.44C FIG.44D FIG.44E

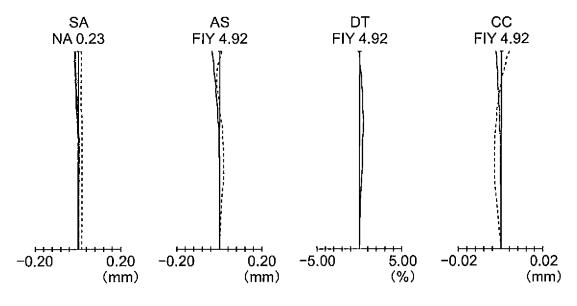


FIG. 45A

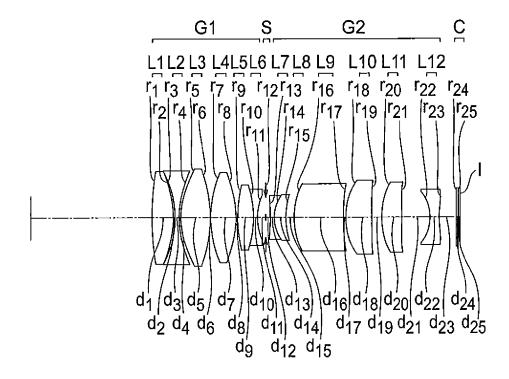


FIG.45B FIG.45C FIG.45D FIG.45E

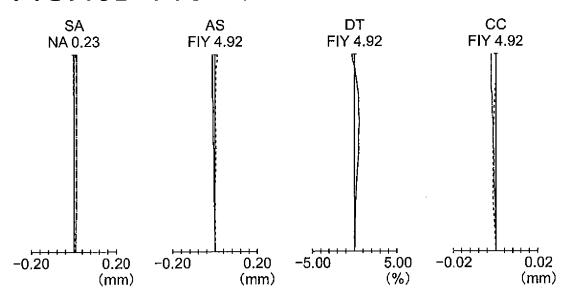


FIG. 46A

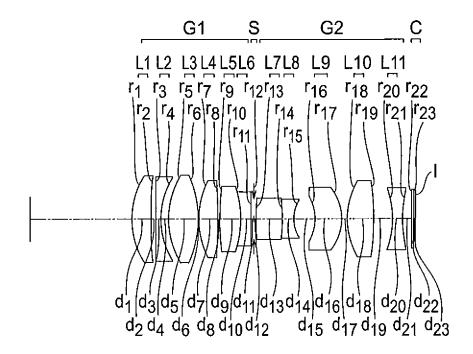


FIG.46B FIG.46C FIG.46D FIG.46E

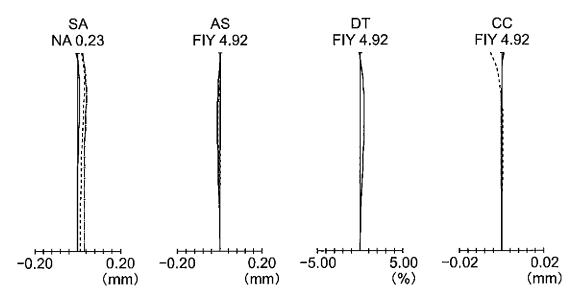


FIG. 47A

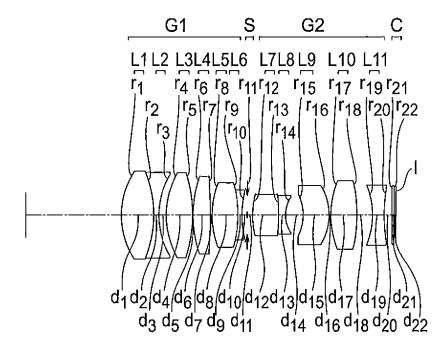


FIG.47B FIG.47C FIG.47D FIG.47E

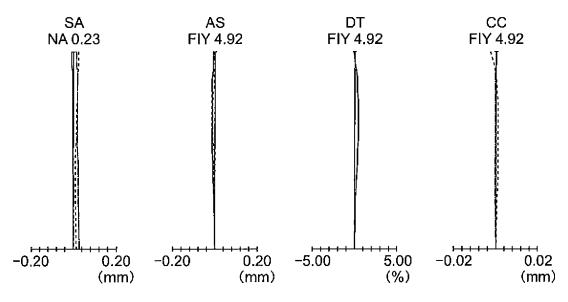


FIG. 48A

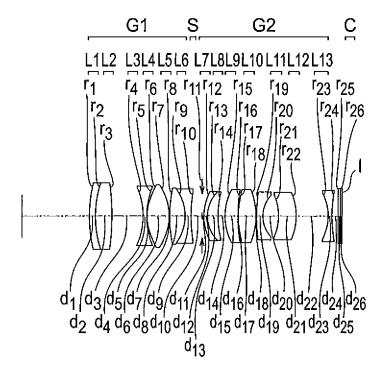


FIG.48B FIG.48C FIG.48D FIG.48E

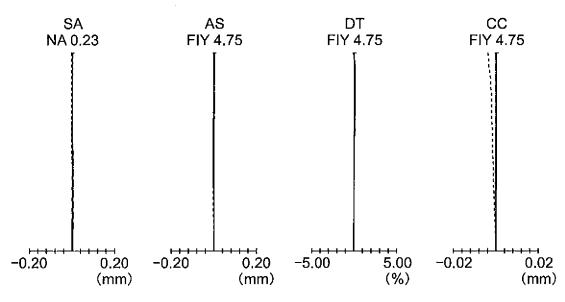


FIG. 49A

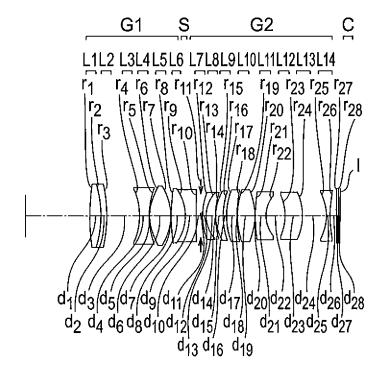


FIG.49B FIG.49C FIG.49D FIG.49E

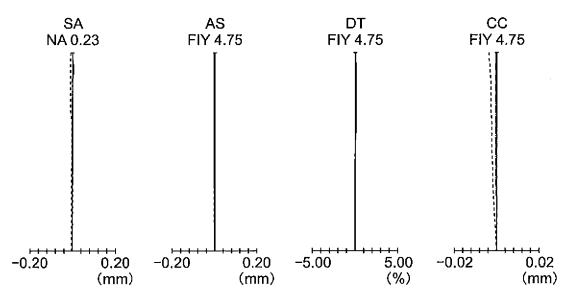


FIG. 50A

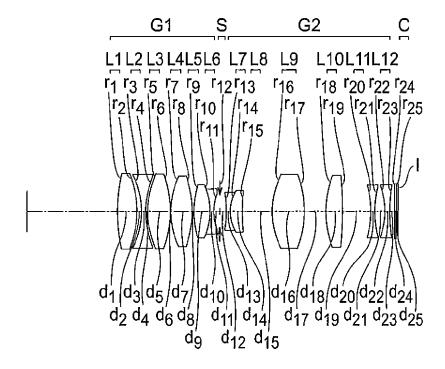


FIG.50B FIG.50C FIG.50D FIG.50E

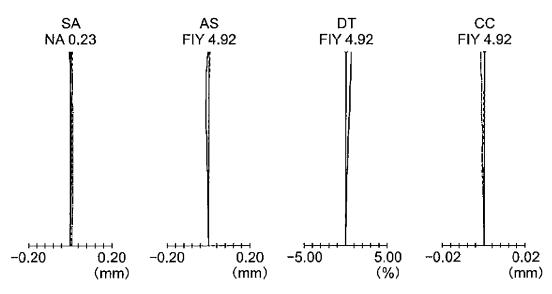


FIG. 51A

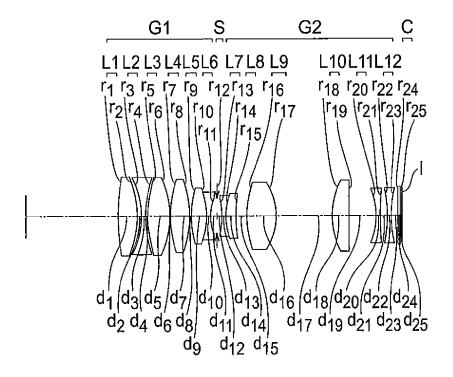


FIG.51B FIG.51C FIG.51D FIG.51E

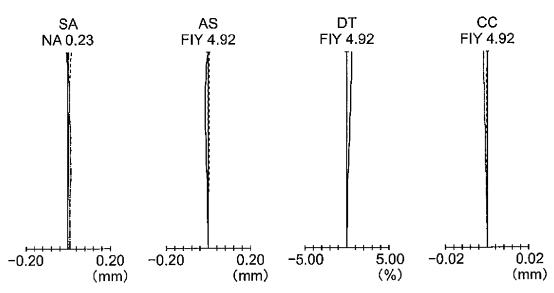


FIG. 52A

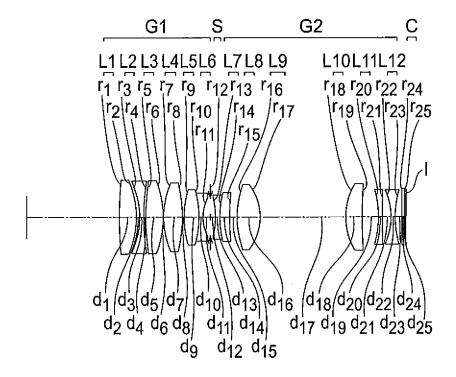


FIG.52B FIG.52C FIG.52D FIG.52E

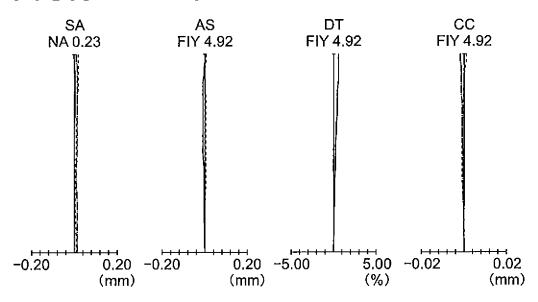


FIG. 53A

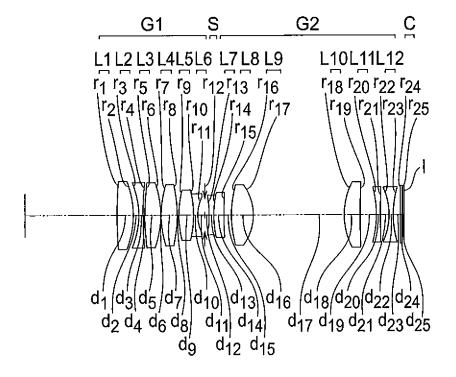


FIG.53B FIG.53C FIG.53D FIG.53E

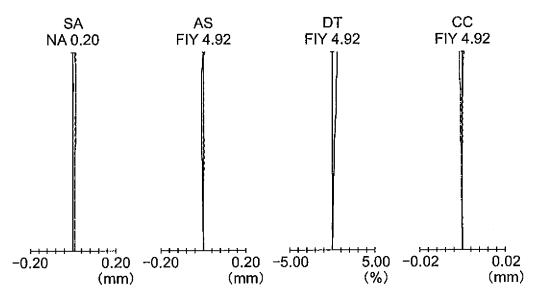


FIG. 54A

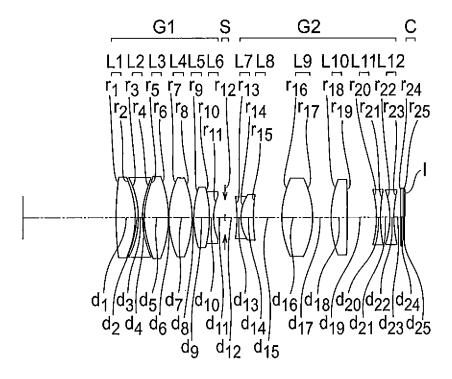


FIG.54B FIG.54C FIG.54D FIG.54E

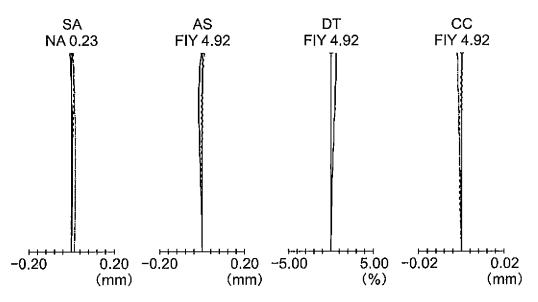


FIG. 55A

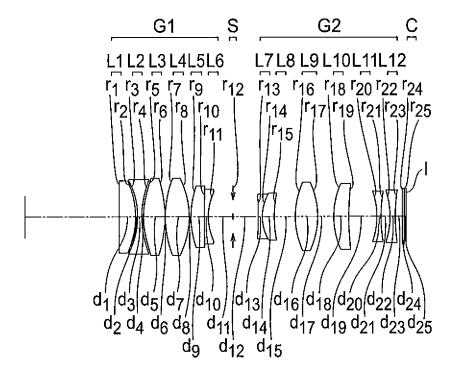


FIG.55B FIG.55C FIG.55D FIG.55E

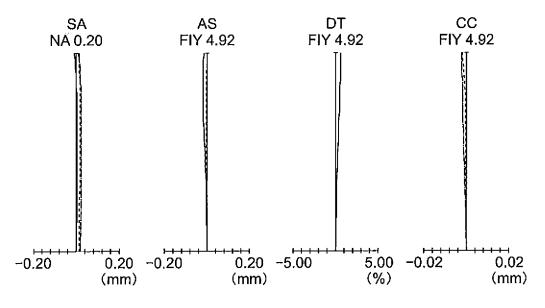


FIG. 56A

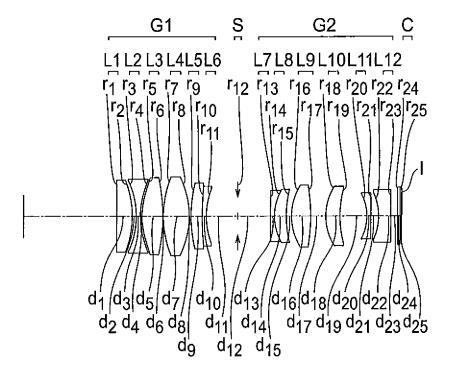


FIG.56B FIG.56C FIG.56D FIG.56E

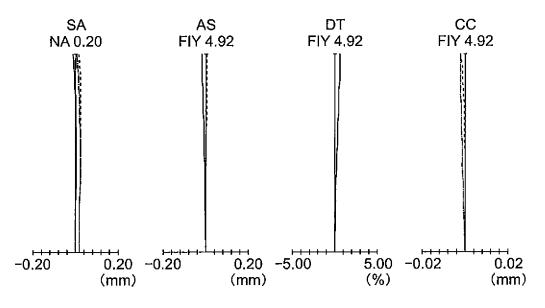


FIG. 57A

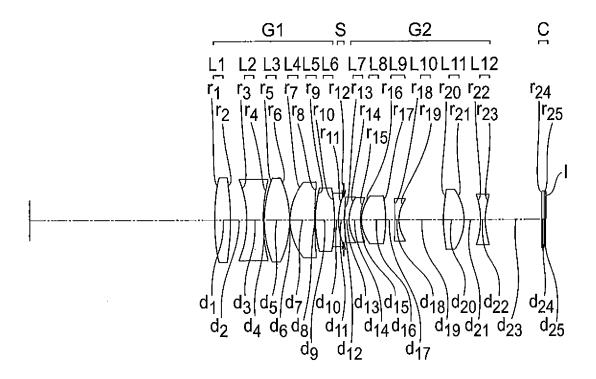


FIG.57B FIG.57C FIG.57D FIG.57E

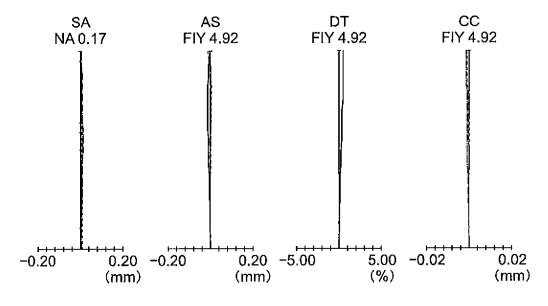


FIG. 58A

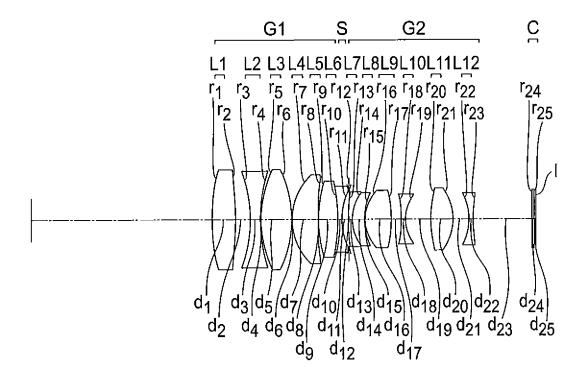


FIG.58B FIG.58C FIG.58D FIG.58E

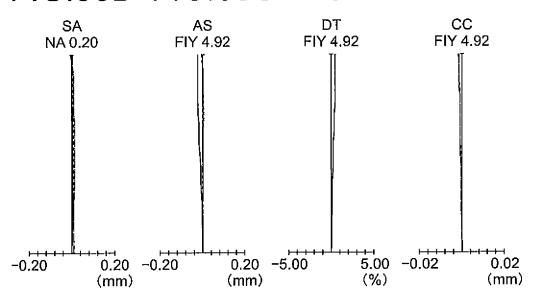


FIG. 59A

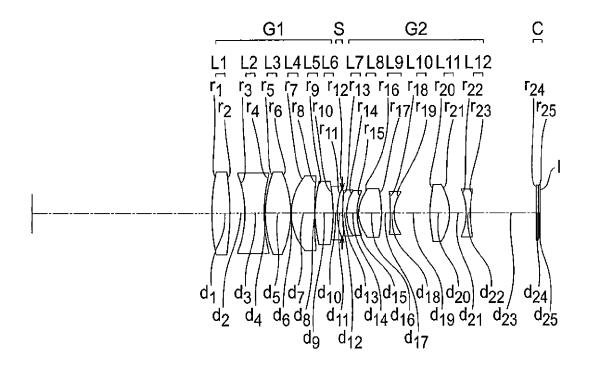


FIG.59B FIG.59C FIG.59D FIG.59E

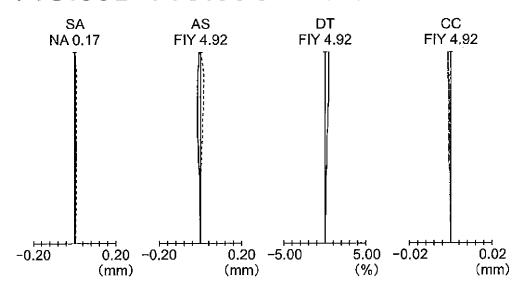


FIG. 60A

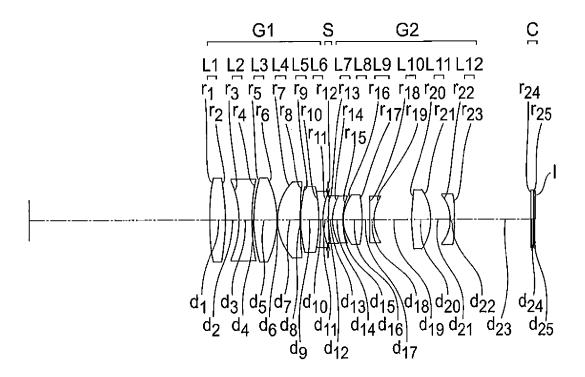


FIG.60B FIG.60C FIG.60D FIG.60E

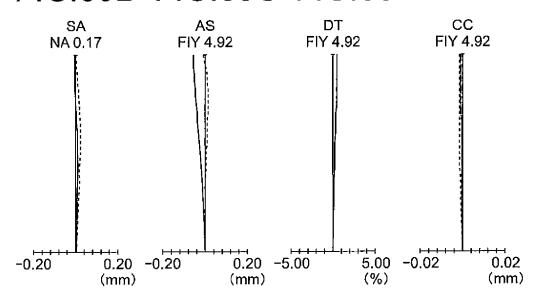


FIG. 61A

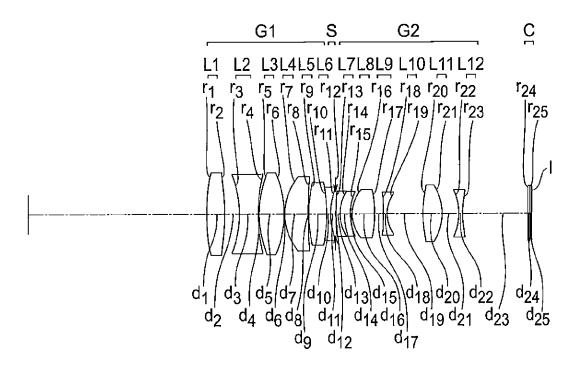


FIG.61B FIG.61C FIG.61D FIG.61E

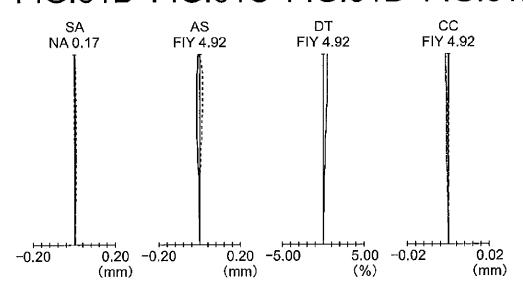


FIG. 62A

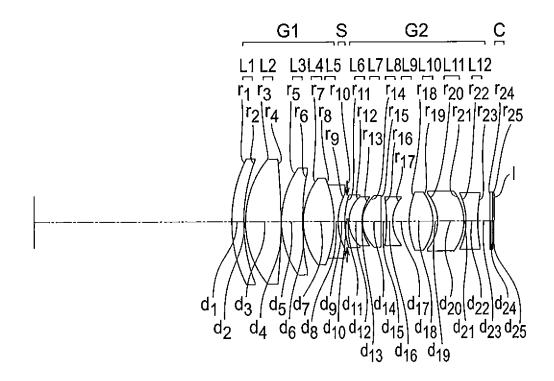


FIG.62B FIG.62C FIG.62D FIG.62E

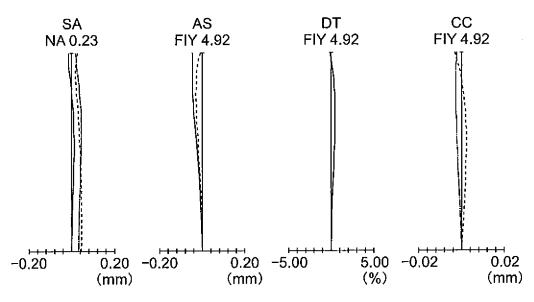


FIG. 63A

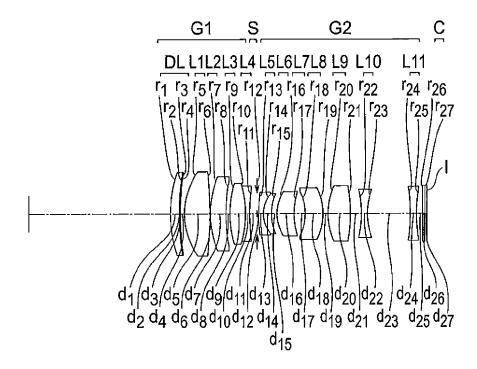


FIG.63B FIG.63C FIG.63D FIG.63E

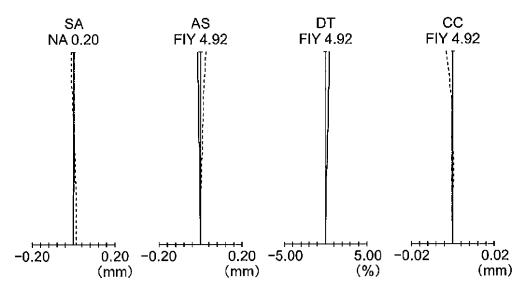


FIG. 64A

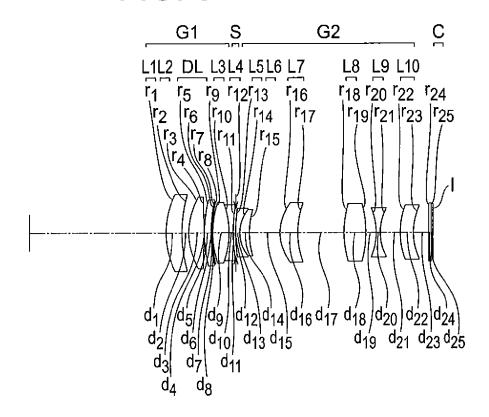


FIG.64B FIG.64C FIG.64D FIG.64E

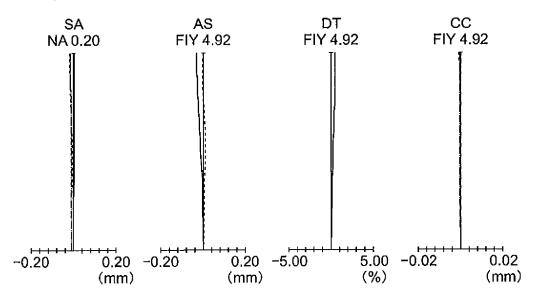


FIG. 65A

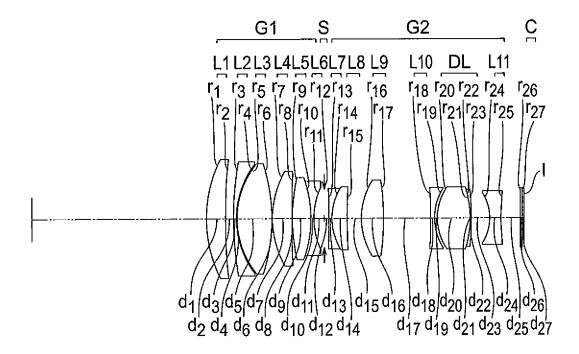


FIG.65B FIG.65C FIG.65D FIG.65E

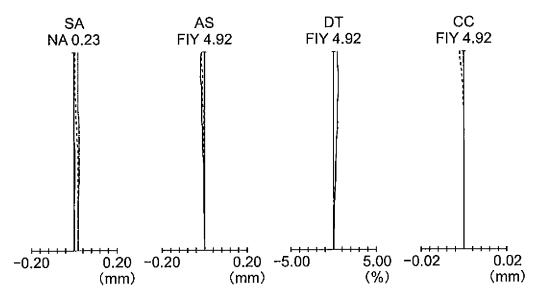


FIG. 66A

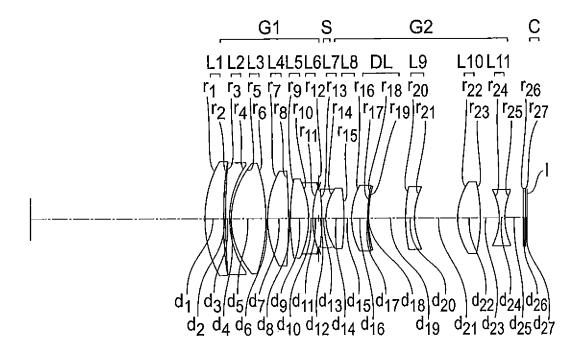


FIG.66B FIG.66C FIG.66D FIG.66E

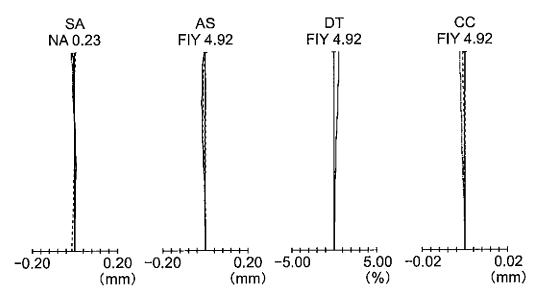


FIG. 67A

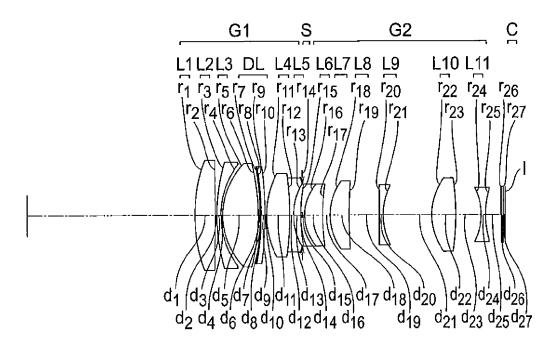


FIG.67B FIG.67C FIG.67D FIG.67E

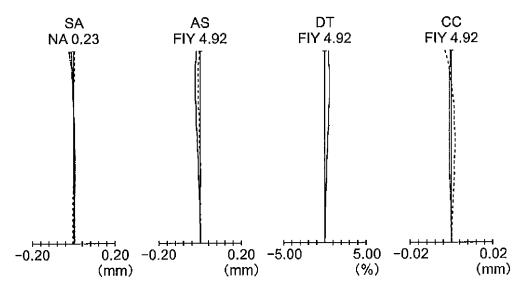


FIG. 68A

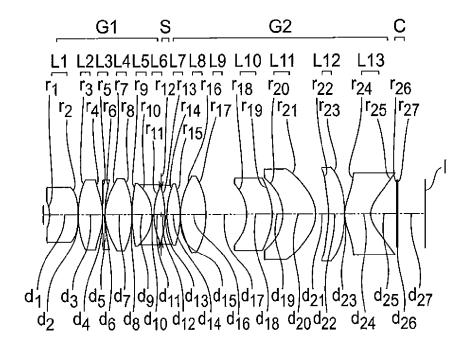


FIG.68B FIG.68C FIG.68D FIG.68E

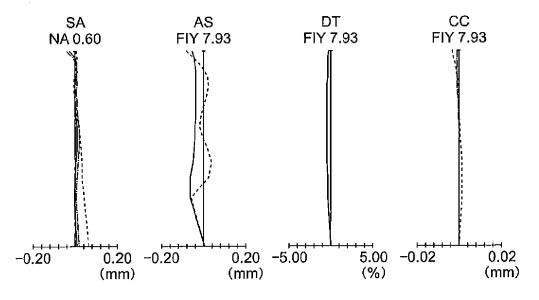


FIG. 69A

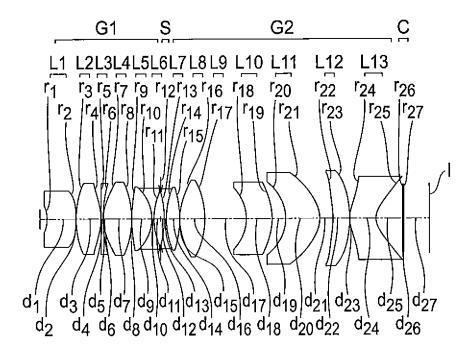


FIG.69B FIG.69C FIG.69D FIG.69E

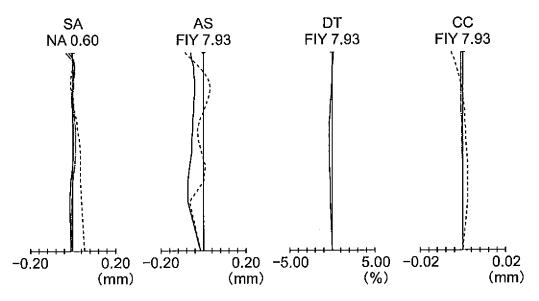


FIG. 70A

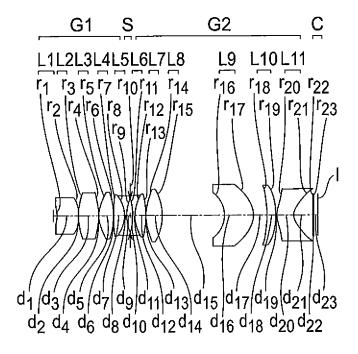


FIG.70B FIG.70C FIG.70D FIG.70E

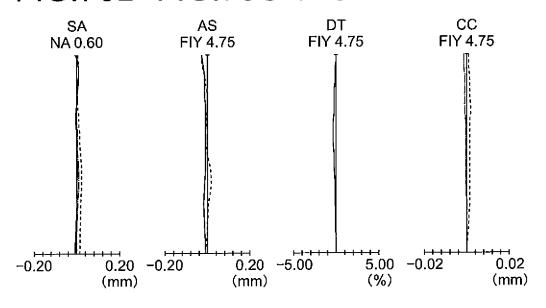


FIG. 71A

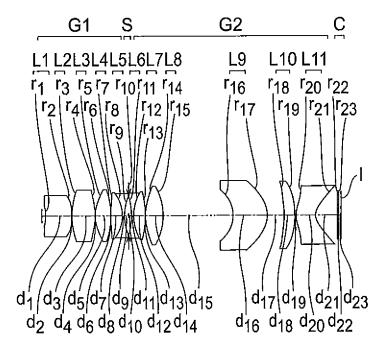


FIG.71B FIG.71C FIG.71D FIG.71E

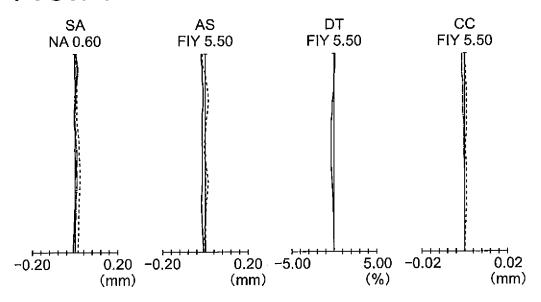


FIG. 72A

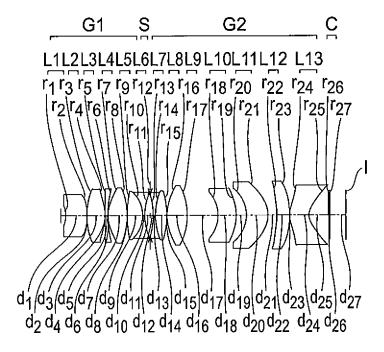


FIG.72B FIG.72C FIG.72D FIG.72E

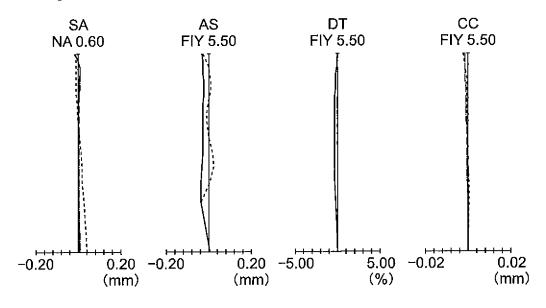


FIG. 73A

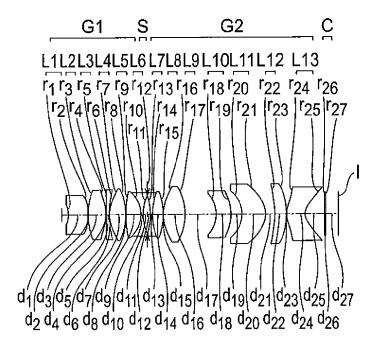


FIG.73B FIG.73C FIG.73D FIG.73E

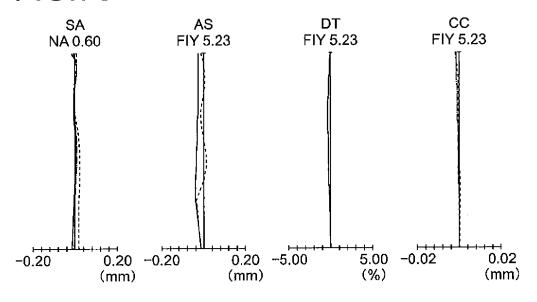


FIG. 74A

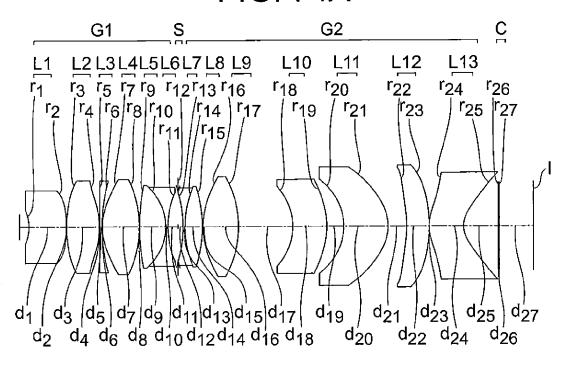


FIG.74B FIG.74C FIG.74D FIG.74E

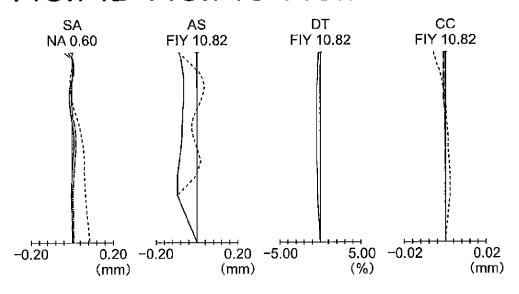


FIG. 75A

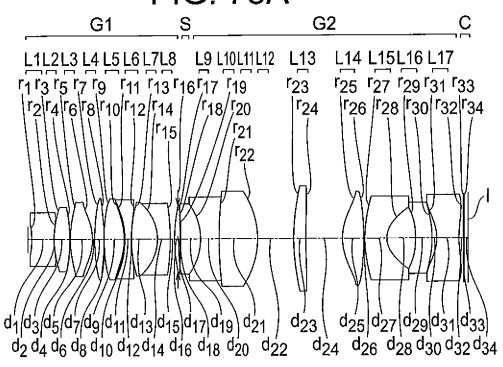


FIG.75B FIG.75C FIG.75D FIG.75E

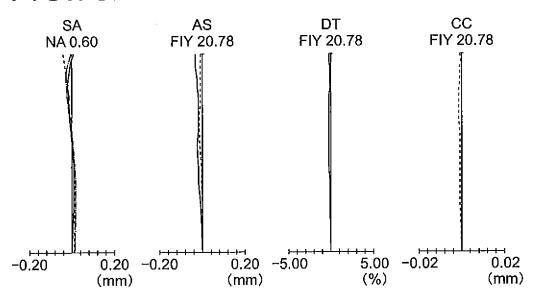


FIG. 76A

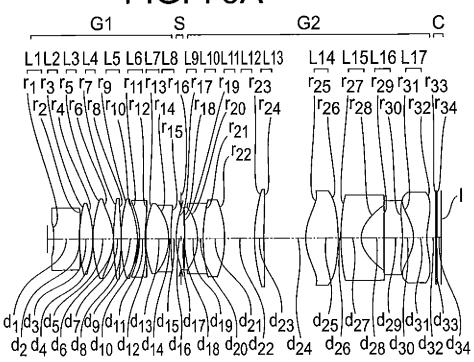


FIG.76B FIG.76C FIG.76D FIG.76E

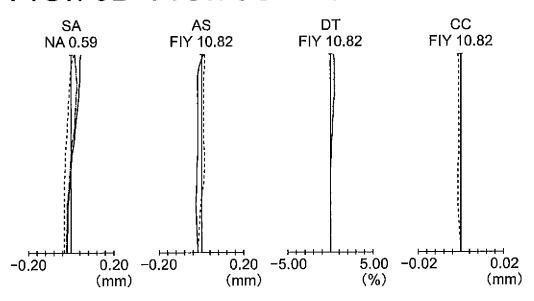


FIG. 77A

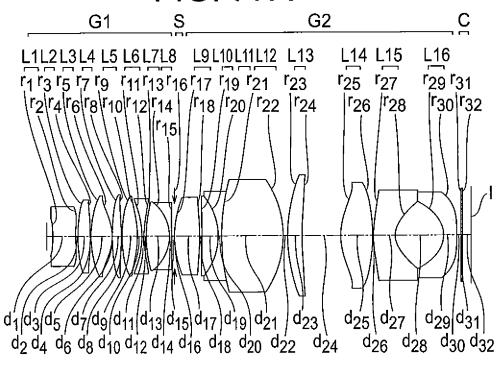


FIG.77B FIG.77C FIG.77D FIG.77E

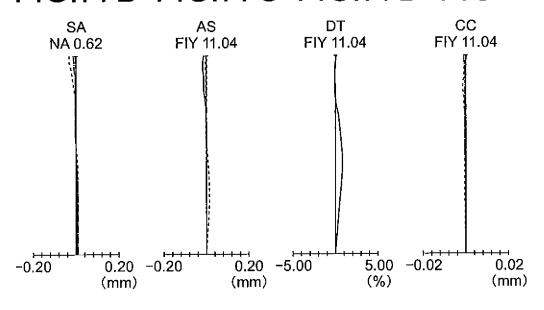


FIG. 78A

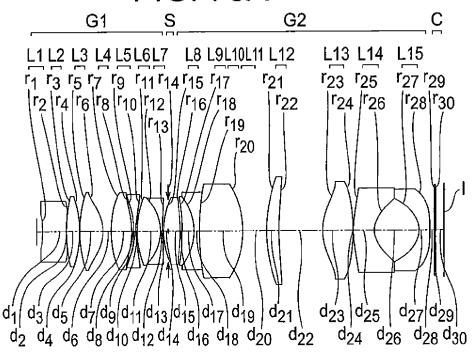


FIG.78B FIG.78C FIG.78D FIG.78E

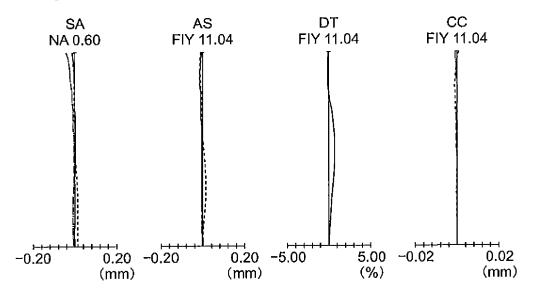


FIG. 79A

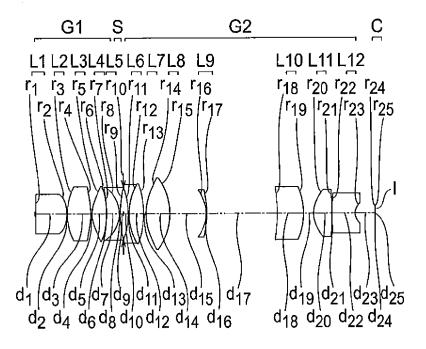


FIG.79B FIG.79C FIG.79D FIG.79E

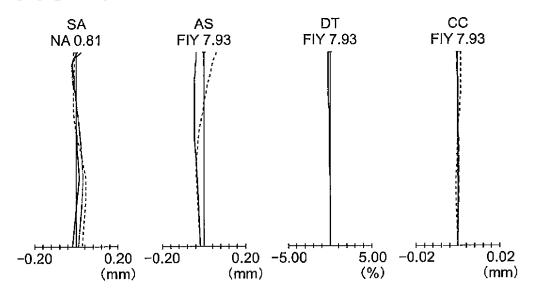


FIG. 80A

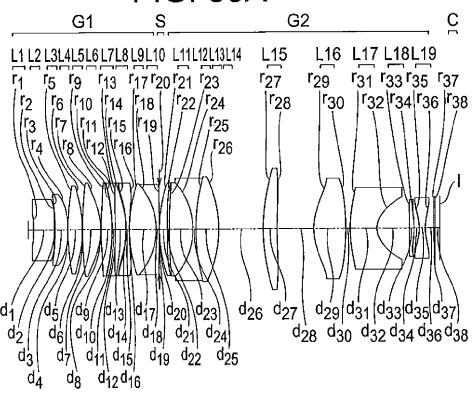


FIG.80B FIG.80C FIG.80D FIG.80E

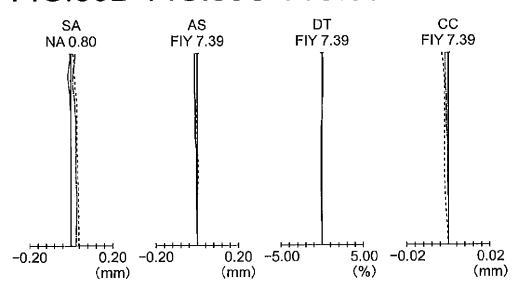


FIG. 81A

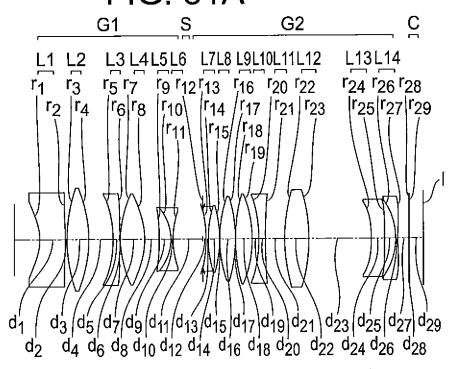
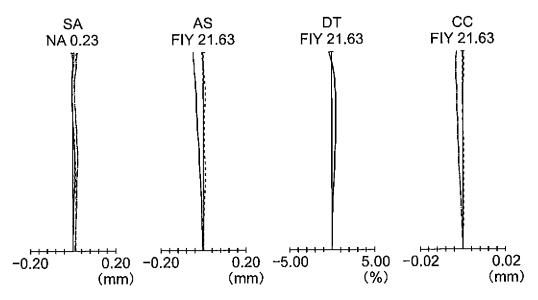


FIG.81B FIG.81C FIG.81D FIG.81E



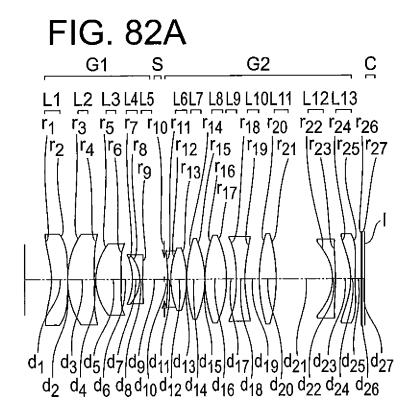


FIG.82B FIG.82C FIG.82D FIG.82E

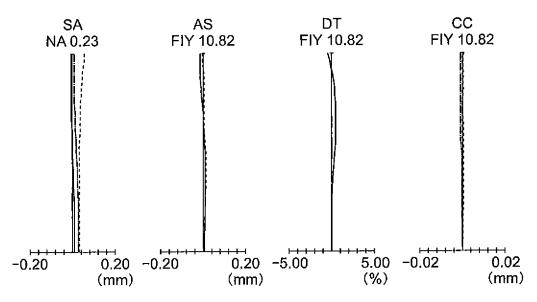


FIG. 83A

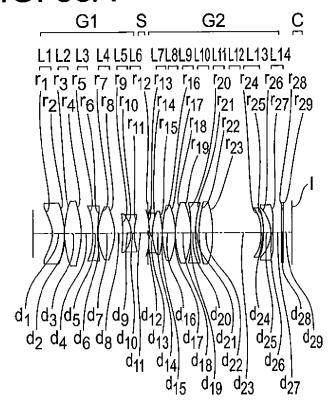


FIG.83B FIG.83C FIG.83D FIG.83E

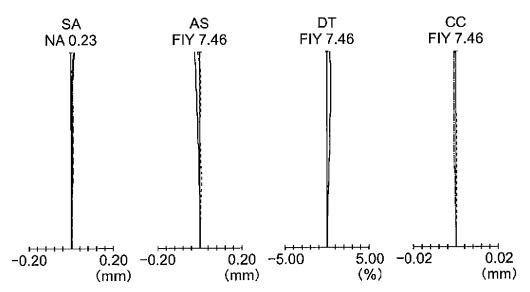


FIG. 84A

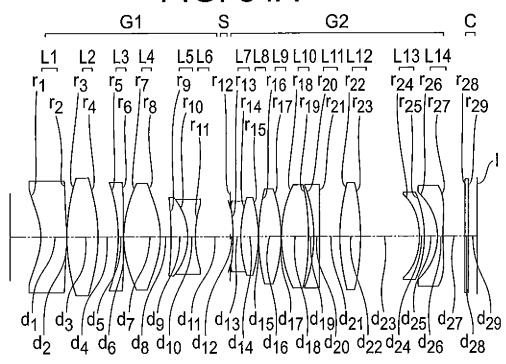


FIG.84B FIG.84C FIG.84D FIG.84E

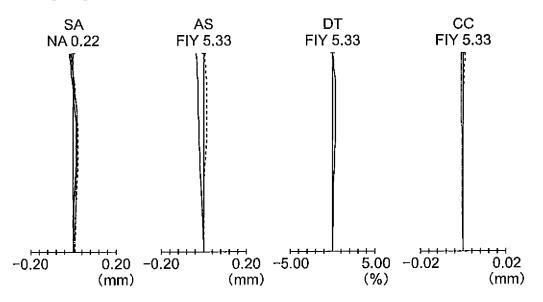


FIG. 85A

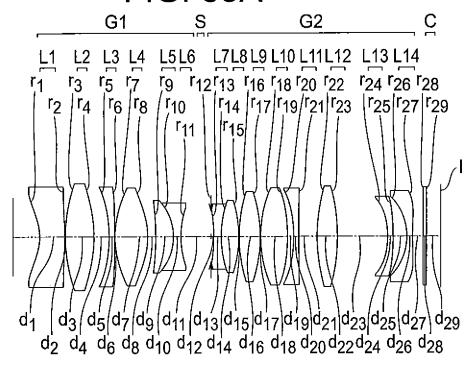


FIG.85B FIG.85C FIG.85D FIG.85E

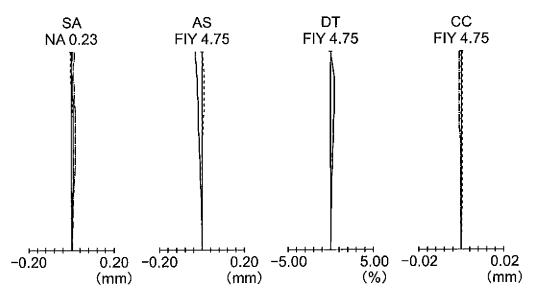


FIG. 86A

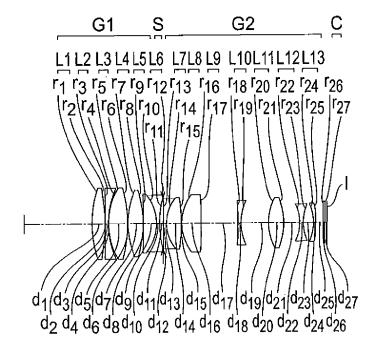


FIG.86B FIG.86C FIG.86D FIG.86E

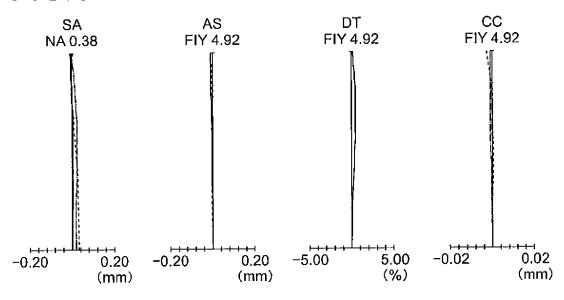


FIG. 87A

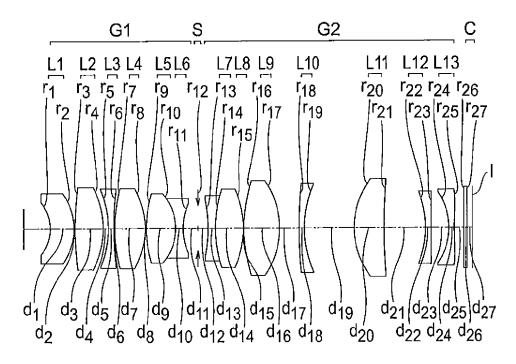


FIG.87B FIG.87C FIG.87D FIG.87E

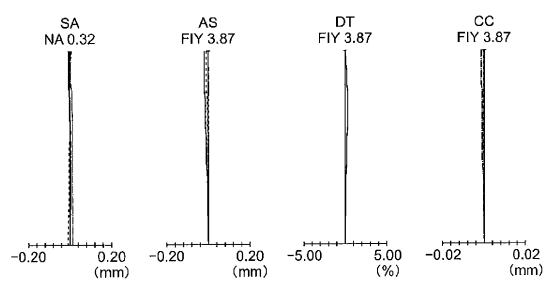


FIG. 88A

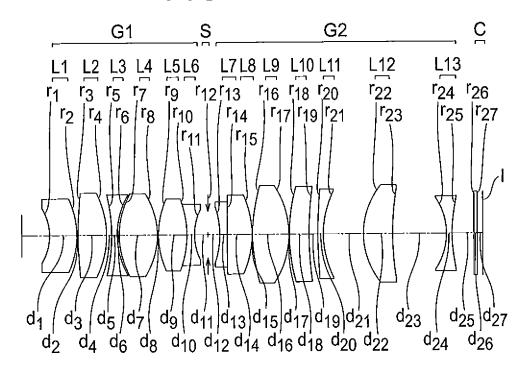


FIG.88B FIG.88C FIG.88D FIG.88E

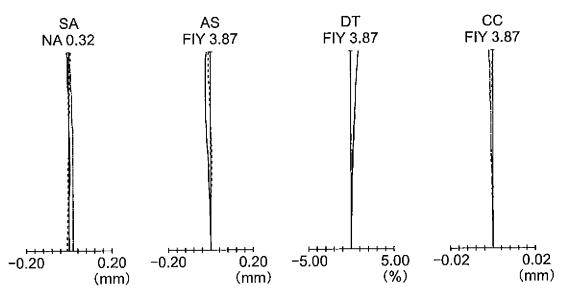


FIG. 89A

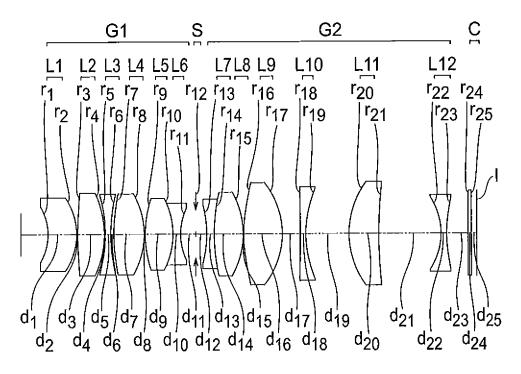


FIG.89B FIG.89C FIG.89D FIG.89E

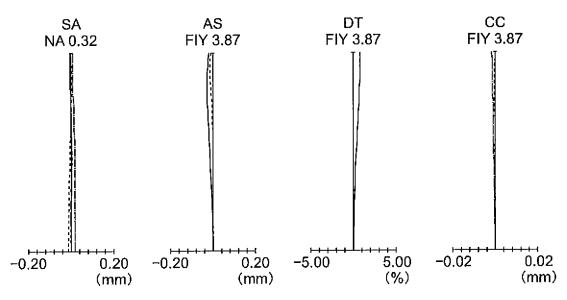


FIG. 90A

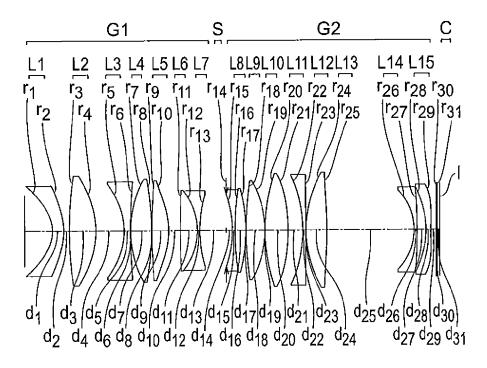


FIG.90B FIG.90C FIG.90D FIG.90E

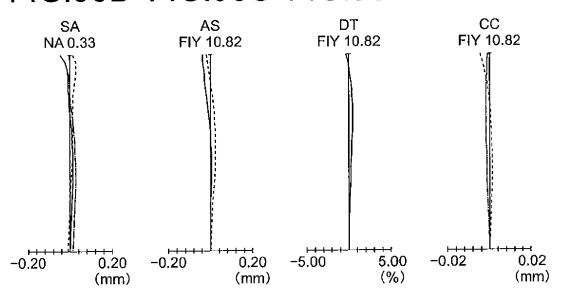


FIG. 91A

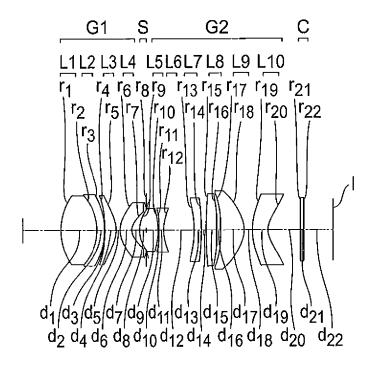


FIG.91B FIG.91C FIG.91D FIG.91E

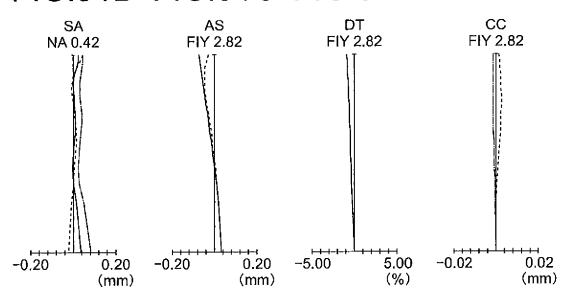


FIG. 92A

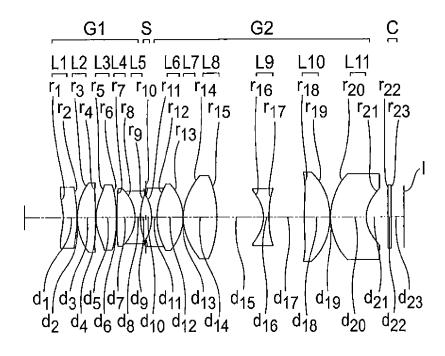


FIG.92B FIG.92C FIG.92D FIG.92E

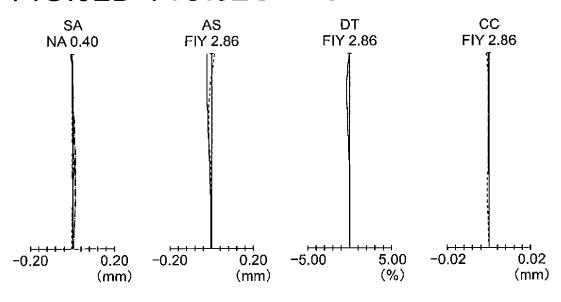


FIG. 93A

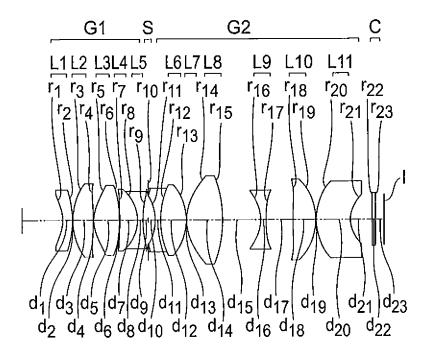


FIG.93B FIG.93C FIG.93D FIG.93E

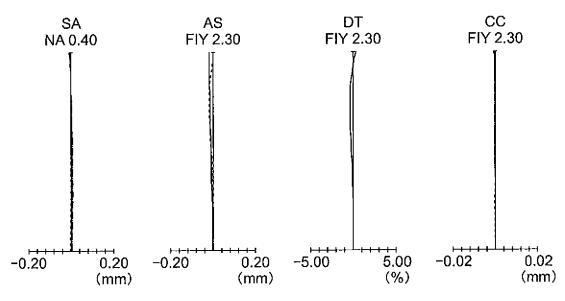


FIG. 94A

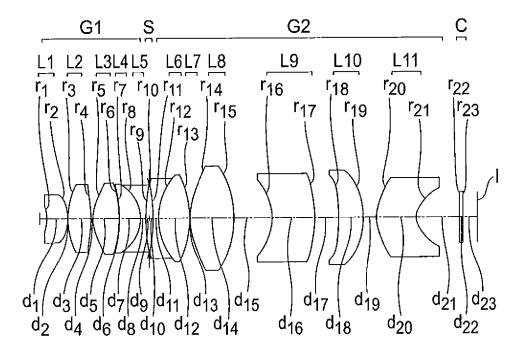


FIG.94B FIG.94C FIG.94D FIG.94E

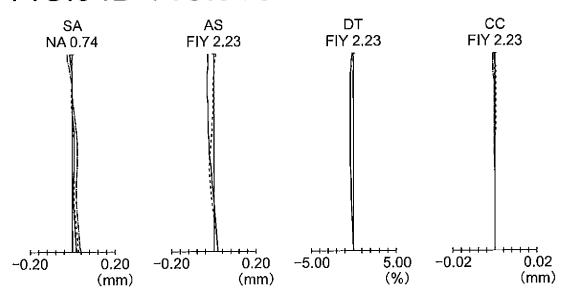


FIG. 95A

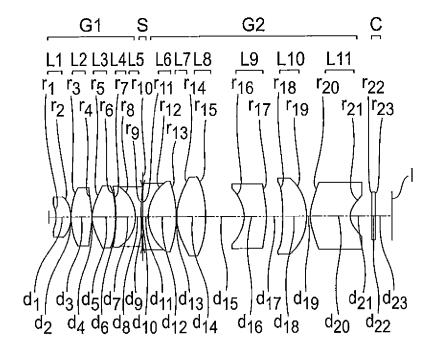


FIG.95B FIG.95C FIG.95D FIG.95E

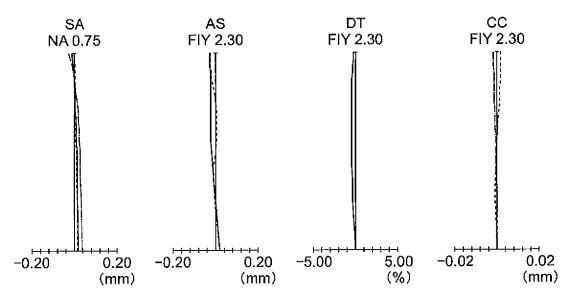


FIG. 96A

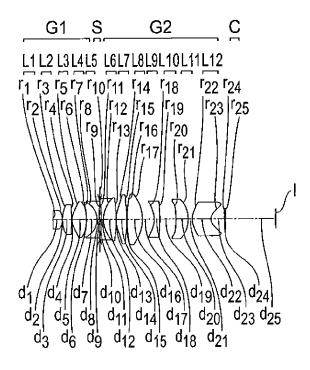


FIG.96B FIG.96C FIG.96D FIG.96E

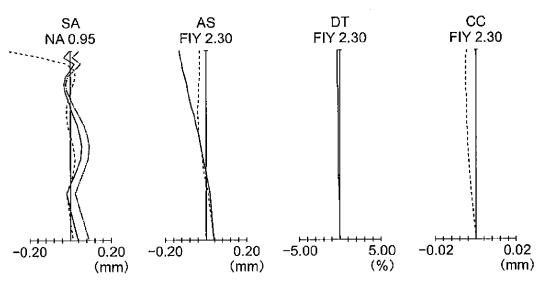


FIG. 97A

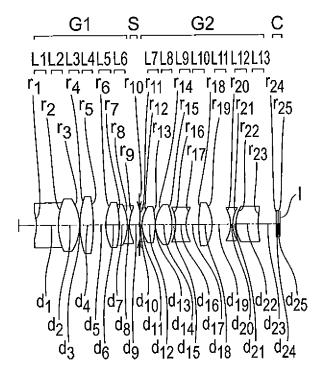


FIG.97B FIG.97C FIG.97D FIG.97E

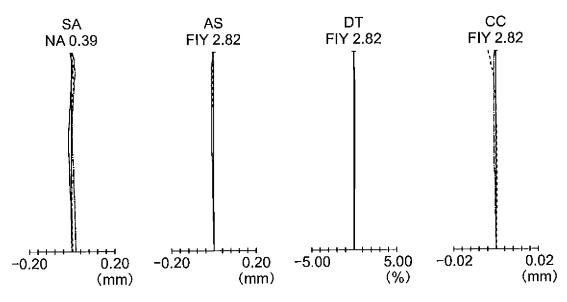


FIG. 98A

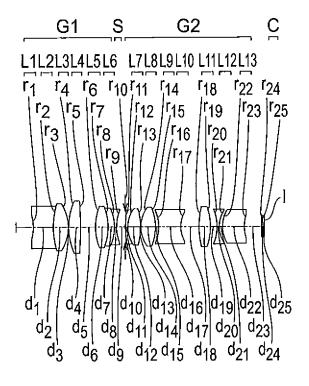


FIG.98B FIG.98C FIG.98D FIG.98E

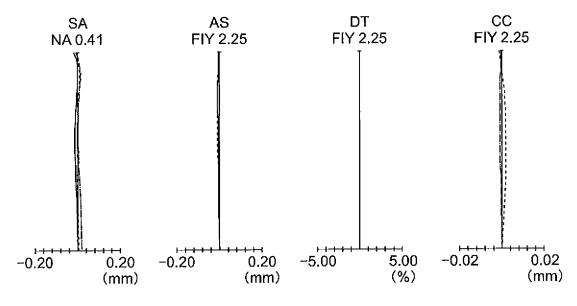


FIG. 99A

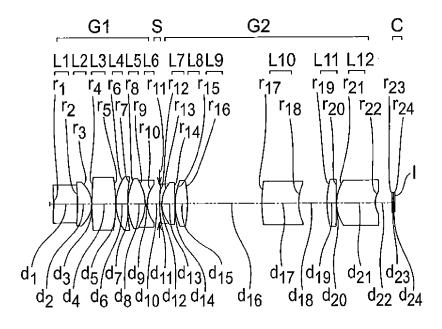


FIG.99B FIG.99C FIG.99D FIG.99E

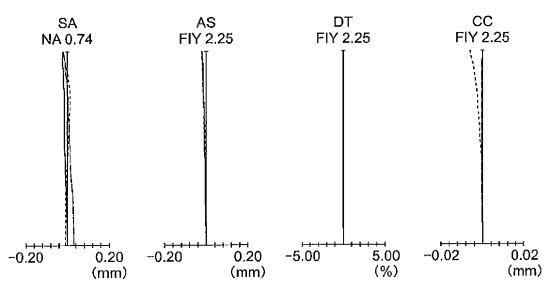


FIG. 100A

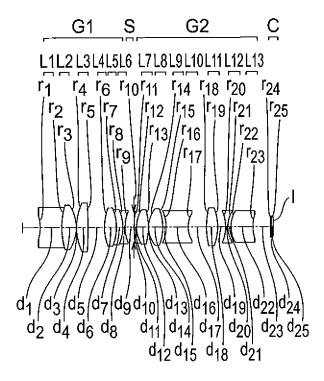


FIG.100B FIG.100C FIG.100D FIG.100E

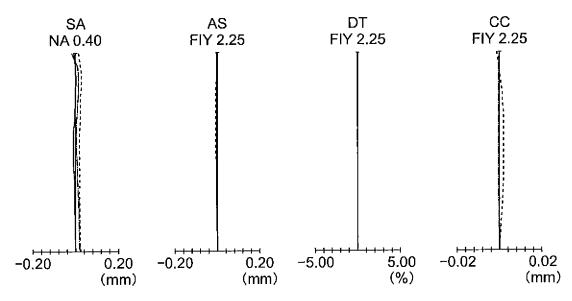


FIG. 101A

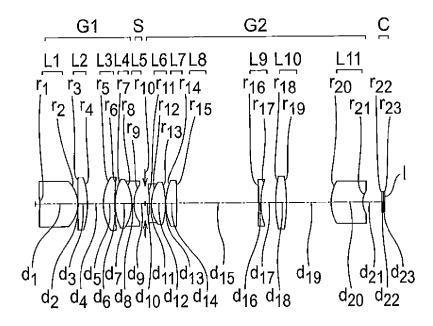


FIG.101B FIG.101C FIG.101D FIG.101E

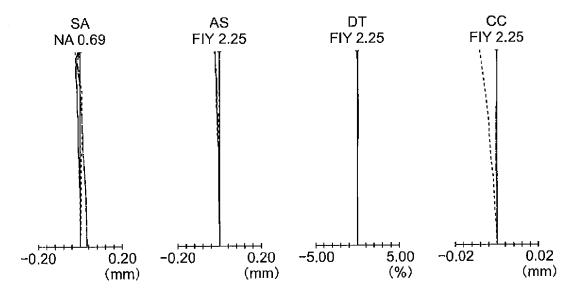


FIG. 102A

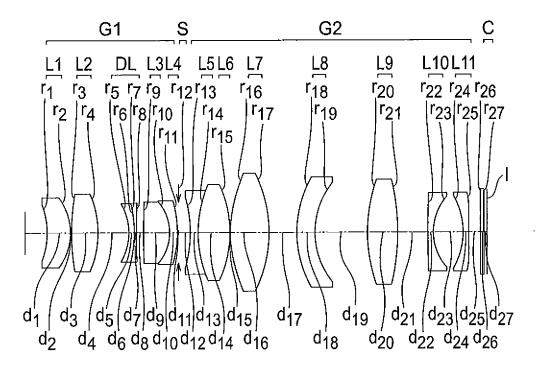


FIG.102B FIG.102C FIG.102D FIG.102E

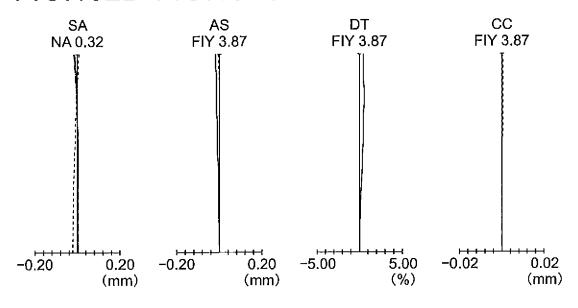


FIG. 103A

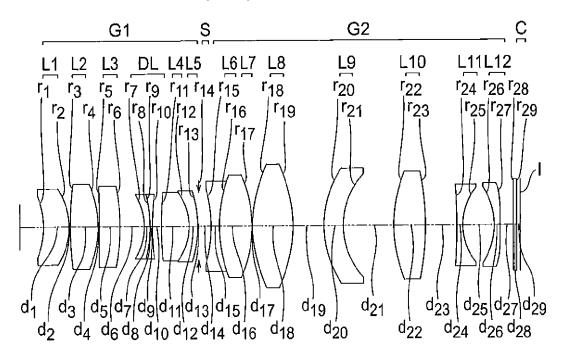


FIG.103B FIG.103C FIG.103D FIG.103E

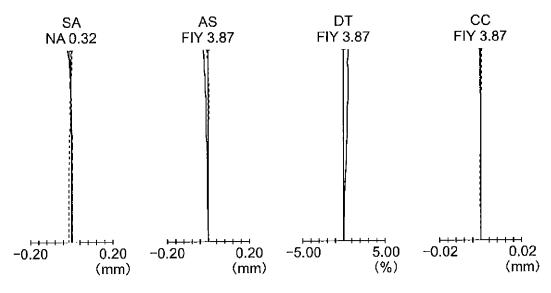


FIG. 104

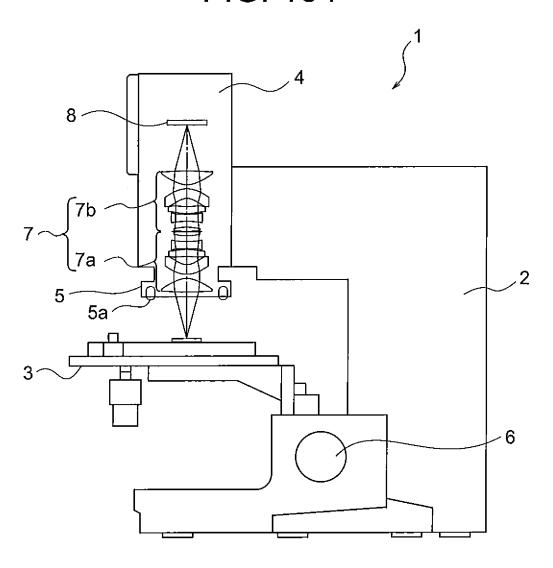


FIG. 105

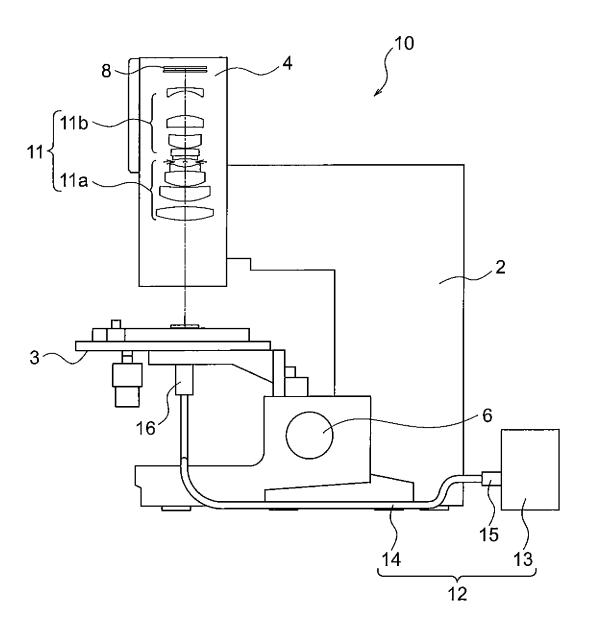


FIG. 106

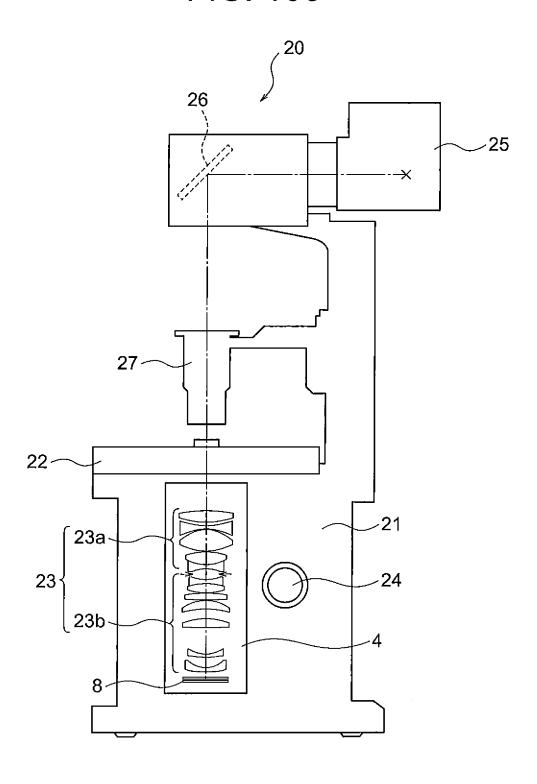


FIG. 107A

May 3, 2016

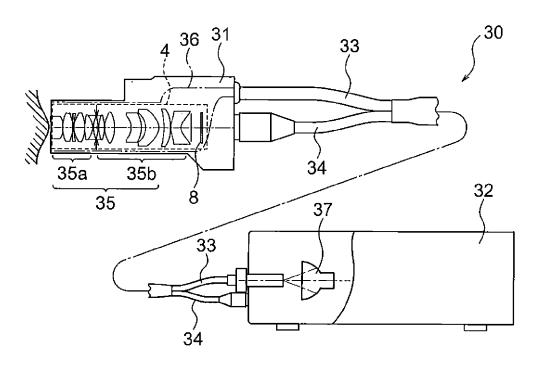
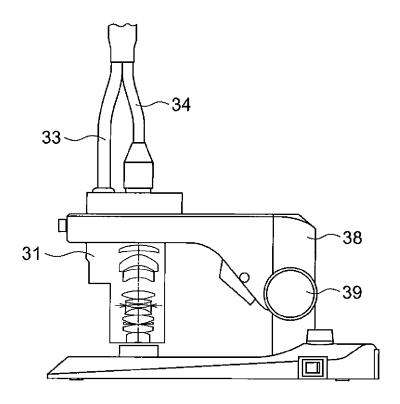


FIG. 107B



OPTICAL SYSTEM AND OPTICAL INSTRUMENT, IMAGE PICKUP APPARATUS, AND IMAGE PICKUP SYSTEM USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a divisional application of U.S. patent application Ser. No. 14/529,885 filed on Oct. 31, 2014, which is a continuation application of PCT/JP2013/075153 filed on Sep. 18, 2013 which is based upon and claims the benefit of priority from Japanese Patent Application No. 2012-208980 filed on Sep. 21, 2012; the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical system, and an 20 (20) are satisfied: optical instrument, an image pickup apparatus, and an image pickup system using the same. $\beta = -1.1$

2. Description of the Related Art

In a case of observing a minute sample, a method in which, first, the overall sample is observed, and a region to be observed in detail is identified, and thereafter the region to be observed in detail is magnified and observed, has hitherto been adopted. As an image pickup apparatus to be used in such method, an image pickup apparatus which magnifies digitally an image that has been captured, and displays the magnified image is available. As an optical system to be used in such image pickup apparatus, an optical system described in Japanese Patent Application Laid-open Publication number 2012-173491 is available. Digital magnification of image is called as digital zooming.

Moreover, if conventional optical systems, such as optical systems for microscope, are differentiated according to a difference of a type of image formation, they will be divided into two types namely, optical systems of finite correction type and optical systems of infinite correction type. In the 40 optical system of finite correction type, an object image is formed at a finite distance by a microscope objective. Whereas, in the optical system of infinite correction type, light emerged from the microscope objective becomes a substantially parallel light beam. Therefore, in the optical system 45 of infinite correction type, an object image is formed by combining the microscope objective and a tube lens.

As aforementioned, in a microscope optical system of the infinite correction type, a microscope objective by which, the light emerged becomes substantially parallel light beam, has 50 been used. As an example of the microscope objective, a microscope objective described in Japanese Patent Application Laid-open Publication No. 2008-185965 is available. The microscope objective described in Japanese Patent Application Laid-open Publication No. 2008-185965 has a 55 numerical aperture (NA) of an extremely large value on an object side (sample side), such that a numerical aperture on the object side is 0.8. This microscope objective is used with the tube lens, and at this time, if a numerical aperture on an image side is small, a bright and sharp image cannot be 60 formed.

SUMMARY OF THE INVENTION

An optical system according to an aspect of the present 65 invention is an optical system which forms an optical image on an image pickup element including a plurality of pixels

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arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,

a first lens unit having a positive refractive power, which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens unit in sdisposed nearest to an image, and

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

the following conditional expressions (15), (16), (19), and (20) are satisfied:

$$\beta \leq -1.1 \tag{15}$$

$$1.0 < WD/BF \tag{19}$$

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 4.0$$
 (20)

where.

 β denotes an imaging magnification of the optical system, NA denotes a numerical aperture on the object side of the optical system,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens,

BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the image,

Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

Moreover, an optical system according to another aspect of the present invention is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts alight intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,

a first lens unit which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the following conditional expressions (16), (21), (23-1), and (24-1) are satisfied:

$$0.08 < NA$$
 (16)

$$0.01 < D_{max} / \phi_s < 3.0$$
 (21)

$$0.6 \le L_L/D_{oi}$$
 (23-1)

$$0.015 \le 1/v d_{min} - 1/v d_{max}$$
 (24-1)

where,

NA denotes a numerical aperture on the object side of the optical system,

 ${\rm D}_{max}$ denotes a maximum distance from among distances on an optical axis of adjacent lenses in the optical system,

 ϕ_s denotes a diameter of the stop,

 L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side $\,^5$ surface of the second image-side lens,

 \mathbf{D}_{ot} denotes a distance on the optical axis from the object to the image,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

 vd_{max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the optical system.

An optical system according to still another aspect of the present invention comprising in order from an object side,

a lens unit Gf having a positive refractive power,

a stop, and

a lens unit Gr having a positive refractive power, and

the following conditional expressions (4-1), (5), (9-1), and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_1/\Sigma d < 0.2$$
 (9-1)

$$-20 < \Delta f_{cd} < d < 20 \tag{13}$$

where

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

 β denotes a projection magnification of the optical system,

 ${\rm d_1}$ denotes a distance on an optical axis from a surface positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit Gr,

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

ed denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

Moreover, an optical system according to still another aspect of the present invention comprising in order from an object side,

a lens unit Gf having a positive refractive power,

a stop, and

a lens unit Gr having a positive refractive power, and the following conditional expression (4-1), (5), (10-1), and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 \le d_2 / \Sigma d \le 2$$
 (10-1)

$$-20 < \Delta f_{cd} < d < 20 \tag{13}$$

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the 65 optical system,

 β denotes a projection magnification of the optical system,

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d₂ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr.

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

ed denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

Moreover, an optical system according to still another aspect of the present invention is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and for which, a pitch of pixels is not more than 5.0 μm, comprising in order from an object side,

a first lens unit which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the following conditional expressions (16), (18), and (25) are satisfied:

$$0.08 < NA$$
 (16)

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) / \epsilon_d < 30$$
(18)

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

NA denotes a numerical aperture on the object side of the optical system,

 $\Delta D_{G1dC} \ \ denotes \ a \ distance \ from \ a \ position \ of \ an \ image \ point \ P_{G1} \ on \ a \ d-line \ up to \ a \ position \ of \ an \ image \ point \ on \ a$ $\ C-line, \ at \ an \ image \ point \ of \ the \ first \ lens \ unit \ with \ respect \ to \ an \ object \ point \ on \ an \ optical \ axis,$

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the 50 image point P_{G1} is let to be an object point of the second lens unit.

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens unit.

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system,

 D_{os} denotes a distance on the optical axis from the object up to the stop, and

 \mathbf{D}_{oi} denotes a distance on the optical axis from the object up to the image, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

Moreover, a microscope which is an example of an optical instrument of the present invention, or an image pickup apparatus of the present invention comprises, the optical system described above, and an image pickup element.

Furthermore, an image pickup system of the present invention comprises, the image pickup apparatus described above, a stage which holds an object, and an illuminating unit which illuminates the object.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 1;

FIG. **2**A, FIG. **2**B, FIG. **2**C, and FIG. **2**D are diagrams 20 showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 1;

FIG. 3 is a cross-sectional view along an optical axis show- 25 ing an optical arrangement of an optical system according to an example 2;

FIG. 4A, FIG. 4B, FIG. 4C, and FIG. 4D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification 30 (CC) respectively, of the optical system according to the example 2;

FIG. 5 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 3;

FIG. 6A, FIG. 6B, FIG. 6C, and FIG. 6D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 3;

FIG. 7 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 4;

FIG. 8A, FIG. 8B, FIG. 8C, and FIG. 8D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a 45 distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 4;

FIG. 9 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to 50 an example 5;

FIG. 10A, FIG. 10B, FIG. 10C, and FIG. 10D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the 55 example 5:

FIG. 11 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 6;

FIG. 12A, FIG. 12B, FIG. 12C, and FIG. 12D are diagrams 60 showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 6;

FIG. 13 is a cross-sectional view along an optical axis 65 showing an optical arrangement of an optical system according to an example 7;

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FIG. 14A, FIG. 14B, FIG. 14C, and FIG. 14D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 7;

FIG. 15A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 15B, FIG. 15C, FIG. 15D, and FIG. 15E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 8;

FIG. **16**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **16**B, FIG. **16**C, FIG. **16**D, and FIG. **16**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 9;

FIG. 17A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 17B, FIG. 17C, FIG. 17D, and FIG. 17E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 10;

FIG. **18**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **18**B, FIG. **18**C, FIG. **18**D, and FIG. **18**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 11;

FIG. **19**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **19**B, FIG. **19**C, FIG. **19**D, and FIG. **19**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 12;

FIG. **20**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **20**B, FIG. **20**C, FIG. **20**D, and FIG. **20**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 13;

FIG. 21A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 21B, FIG. 21C, FIG. 21D, and FIG. 21E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 14;

FIG. 22A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 22B, FIG. 22C, FIG. 22D, and FIG. 22E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 15;

FIG. 23A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 23B, FIG. 23C, FIG. 23D, and FIG. 23E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 16;

FIG. 24A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 24B, FIG. 24C, FIG. 24D, and FIG. 24E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 17;

FIG. 25A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 25B, FIG. 25C,

FIG. **25**D, and FIG. **25**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 18;

FIG. **26**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **26**B, FIG. **26**C, FIG. **26**D, and FIG. **26**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 19;

FIG. 27A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 27B, FIG. 27C, FIG. 27D, and FIG. 27E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 15 the optical system according to an example 20;

FIG. **28**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **28**B, FIG. **28**C, FIG. **28**D, and FIG. **28**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 20 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 21;

FIG. 29A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 29B, FIG. 29C, FIG. 29D, and FIG. 29E are diagrams showing a spherical 25 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 22;

FIG. **30**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **30**B, FIG. **30**C, 30 FIG. **30**D, and FIG. **30**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **23**;

FIG. **31**A is a cross-sectional view along an optical axis 35 showing an optical arrangement, and FIG. **31**B, FIG. **31**C, FIG. **31**D, and FIG. **31**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 24;

FIG. 32A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 32B, FIG. 32C, FIG. 32D, and FIG. 32E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 45 the optical system according to an example 25;

FIG. 33A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 33B, FIG. 33C, FIG. 33D, and FIG. 33E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 50 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 26;

FIG. **34**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **34**B, FIG. **34**C, FIG. **34**D, and FIG. **34**E are diagrams showing a spherical 55 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 27;

FIG. 35A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 35B, FIG. 35C, 60 FIG. 35D, and FIG. 35E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 28;

FIG. **36**A is a cross-sectional view along an optical axis 65 showing an optical arrangement, and FIG. **36**B, FIG. **36**C, FIG. **36**D, and FIG. **36**E are diagrams showing a spherical

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aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 29;

FIG. 37A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 37B, FIG. 37C, FIG. 37D, and FIG. 37E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 30;

FIG. 38A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 38B, FIG. 38C, FIG. 38D, and FIG. 38E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 31;

FIG. 39A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 39B, FIG. 39C, FIG. 39D, and FIG. 39E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 32;

FIG. **40**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **40**B, FIG. **40**C, FIG. **40**D, and FIG. **40**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 33;

FIG. 41A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 41B, FIG. 41C, FIG. 41D, and FIG. 41E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 34;

FIG. **42**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **42**B, FIG. **42**C, FIG. **42**D, and FIG. **42**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **35**;

FIG. **43**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **43**B, FIG. **43**C, FIG. **43**D, and FIG. **43**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 36;

FIG. 44A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 44B, FIG. 44C, FIG. 44D, and FIG. 44E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 37;

FIG. **45**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **45**B, FIG. **45**C, FIG. **45**D, and FIG. **45**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **38**;

FIG. **46**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **46**B, FIG. **46**C, FIG. **46**D, and FIG. **46**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 39;

FIG. 47A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 47B, FIG. 47C, FIG. 47D, and FIG. 47E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 40;

FIG. **48**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **48**B, FIG. **48**C, FIG. **48**D, and FIG. **48**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 41;

FIG. **49**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **49**B, FIG. **49**C, FIG. **49**D, and FIG. **49**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **42**;

FIG. **50**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **50**B, FIG. **50**C, FIG. **50**D, and FIG. **50**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 20 the optical system according to an example 43;

FIG. **51**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **51**B, FIG. **51**C, FIG. **51**D, and FIG. **51**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 25 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 44;

FIG. **52**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **52**B, FIG. **52**C, FIG. **52**D, and FIG. **52**E are diagrams showing a spherical 30 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 45;

FIG. **53**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **53**B, FIG. **53**C, 35 FIG. **53**D, and FIG. **53**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 46;

FIG. **54**A is a cross-sectional view along an optical axis 40 showing an optical arrangement, and FIG. **54**B, FIG. **54**C, FIG. **54**D, and FIG. **54**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 47;

FIG. **55**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **55**B, FIG. **55**C, FIG. **55**D, and FIG. **55**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 50 the optical system according to an example 48;

FIG. **56**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **56**B, FIG. **56**C, FIG. **56**D, and FIG. **56**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 55 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 49;

FIG. **57**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **57**B, FIG. **57**C, FIG. **57**D, and FIG. **57**E are diagrams showing a spherical 60 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 50;

FIG. **58**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **58**B, FIG. **58**C, 65 FIG. **58**D, and FIG. **58**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

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a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 51;

FIG. **59**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **59**B, FIG. **59**C, FIG. **59**D, and FIG. **59**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 52;

FIG. **60**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **60**B, FIG. **60**C, FIG. **60**D, and FIG. **60**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **53**;

FIG. **61**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **61**B, FIG. **61**C, FIG. **61**D, and FIG. **61**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **54**;

FIG. **62**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **62**B, FIG. **62**C, FIG. **62**D, and FIG. **62**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 55;

FIG. 63A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 63B, FIG. 63C, FIG. 63D, and FIG. 63E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 56;

FIG. **64**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **64**B, FIG. **64**C, FIG. **64**D, and FIG. **64**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 57;

FIG. **65**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **65**B, FIG. **65**C, FIG. **65**D, and FIG. **65**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **58**;

FIG. **66**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **66**B, FIG. **66**C, FIG. **66**D, and FIG. **66**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 59;

FIG. **67**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **67**B, FIG. **67**C, FIG. **67**D, and FIG. **67**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 60;

FIG. **68**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **68**B, FIG. **68**C, FIG. **68**D, and FIG. **68**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 61;

FIG. **69**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **69**B, FIG. **69**C, FIG. **69**D, and FIG. **69**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 62;

FIG. **70**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **70**B, FIG. **70**C, FIG. **70**D, and FIG. **70**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 63;

FIG. 71A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 71B, FIG. 71C, FIG. 71D, and FIG. 71E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 64;

FIG. **72**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **72**B, FIG. **72**C, FIG. **72**D, and FIG. **72**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 20 the optical system according to an example 65;

FIG. 73A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 73B, FIG. 73C, FIG. 73D, and FIG. 73E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 25 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 66;

FIG. 74A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 74B, FIG. 74C, FIG. 74D, and FIG. 74E are diagrams showing a spherical 30 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 67;

FIG. 75A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 75B, FIG. 75C, 35 FIG. 75D, and FIG. 75E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 68;

FIG. **76**A is a cross-sectional view along an optical axis 40 showing an optical arrangement, and FIG. **76**B, FIG. **76**C, FIG. **76**D, and FIG. **76**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 69;

FIG. 77A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 77B, FIG. 77C, FIG. 77D, and FIG. 77E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 50 the optical system according to an example 70;

FIG. **78**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **78**B, FIG. **78**C, FIG. **78**D, and FIG. **78**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 55 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 71;

FIG. **79**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **79**B, FIG. **79**C, FIG. **79**D, and FIG. **79**E are diagrams showing a spherical 60 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **72**;

FIG. **80**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **80**B, FIG. **80**C, 65 FIG. **80**D, and FIG. **80**e are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

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a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 73;

FIG. **81**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **81**B, FIG. **81**C, FIG. **81**D, and FIG. **81**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 74;

FIG. **82**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **82**B, FIG. **82**C, FIG. **82**D, and FIG. **82**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 75;

FIG. **83**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **83**B, FIG. **83**C, FIG. **83**D, and FIG. **83**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 76;

FIG. **84**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **84**B, FIG. **84**C, FIG. **84**D, and FIG. **84**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 77;

FIG. **85**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **85**B, FIG. **85**C, FIG. **85**D, and FIG. **85**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 78;

FIG. **86**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **86**B, FIG. **86**C, FIG. **86**D, and FIG. **86**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 79;

FIG. **87**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **87**B, FIG. **87**C, FIG. **87**D, and FIG. **87**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 80;

FIG. **88**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **88**B, FIG. **88**C, FIG. **88**D, and FIG. **88**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 81;

FIG. **89**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **89**B, FIG. **89**C, FIG. **89**D, and FIG. **89**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 82;

FIG. 90A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 90B, FIG. 90C, FIG. 90D, and FIG. 90E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 83;

FIG. 91A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 91B, FIG. 91C, FIG. 91D, and FIG. 91E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 84;

FIG. **92**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **92**B, FIG. **92**C, FIG. **92**D, and FIG. **92**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 85;

FIG. 93A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 93B, FIG. 93C, FIG. 93D, and FIG. 93E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 86;

FIG. **94**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **94**B, FIG. **94**C, FIG. **94**D, and FIG. **94**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 20 the optical system according to an example 87;

FIG. **95**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **95**B, FIG. **95**C, FIG. **95**D, and FIG. **95**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 25 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 88;

FIG. 96A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 96B, FIG. 96C, FIG. 96D, and FIG. 96E are diagrams showing a spherical 30 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 89;

FIG. **97**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **97**B, FIG. **97**C, 35 FIG. **97**D, and FIG. **97**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 90;

FIG. **98**A is a cross-sectional view along an optical axis 40 showing an optical arrangement, and FIG. **98**B, FIG. **98**C, FIG. **98**D, and FIG. **98**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 91;

FIG. **99**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **99**B, FIG. **99**C, FIG. **99**D, and FIG. **99**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 50 the optical system according to an example 92;

FIG. 100A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 100B, FIG. 100C, FIG. 100D, and FIG. 100E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 93;

However, an optical system may be equipped with a focusing function.

An optical system according to a first embodiment will be described below. The optical system according to the first embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens

FIG. 101A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 101B, FIG. 101C, FIG. 101D, and FIG. 101E are diagrams showing a spherical 60 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 94;

FIG. 102Å is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 102B, FIG. 102C, 65 FIG. 102D, and FIG. 102E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

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a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 95;

FIG. 103A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 103B, FIG. 103C, FIG. 103D, and FIG. 103E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 96;

FIG. 104 is a diagram showing an arrangement of a microscope which is an optical instrument;

FIG. 105 is a diagram showing an arrangement of another microscope which is an optical instrument;

FIG. 106 is a diagram showing an arrangement of still another microscope which is an optical instrument; and

FIG. 107A is a diagram showing an arrangement of still another microscope which is an optical instrument, and FIG. 107B is a diagram showing a state that the microscope is fixed.

DETAILED DESCRIPTION OF THE INVENTION

Prior to description of examples, an action and effect of embodiments according to certain aspects of the present embodiment will be described below. At the time of describing concretely the action and effect of the present embodiment, the description will be made by citing specific examples. However, similar to cases of examples that will be described later, aspects to be exemplified are only some of the aspects included in the embodiment, and there are a large number of variations in those aspects. Consequently, the present invention is not restricted to aspects that will be exemplified.

For instance, in optical systems from an optical system according to a first embodiment up to an optical system according to a seventh embodiment, by imparting a function of an objective lens to a lens unit Gf, and by imparting a function of an image forming lens to a lens unit Gr, it is possible to form an optical system of a microscope as an optical instrument. An embodiment of the microscope will be described later.

In the following description, a 'sample image' is let to be an 'image' appropriately, and a 'sample' is let to be an 'object' appropriately.

Moreover, in the following description, a variable (such as, a focal length, an imaging magnification, and a numerical aperture) of which, a value changes with a wavelength, is with reference to a d-line unless specifically noted. Moreover, β is used for a magnification of an overall optical system, but β has been described as a projection magnification or an imaging magnification. Furthermore, optical systems of the following embodiments are optical systems with a fixed focal length. However, an optical system may be equipped with a focusing function.

An optical system according to a first embodiment will be described below. The optical system according to the first embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and includes at least one pair of lenses which satisfies the following conditional expressions (1), (2), and (3), and one lens in the pair of lenses is included in the lens unit Gf, and the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OB}/r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OB} / r_{TL} < -0.9$$
 (2)

$$-0.1 < (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) < 0.1$$
 (3)

where.

 r_{OBf} denotes a paraxial radius of curvature of an object-side surface of the one lens in the pair of lenses,

 r_{OBr} denotes a paraxial radius of curvature of an image-side surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 \mathbf{r}_{TLr} denotes a paraxial radius of curvature of an image-side surface of the other lens in the pair of lenses,

 $d_{O\!B}$ denotes a thickness on the optical axis of the one lens $\,$ 10 in the pair of lenses, and

 d_{TL} denotes a thickness on the optical axis of the other lens in the pair of lenses.

The optical system according to the first embodiment includes the lens unit Gf having a positive refractive power, 15 the stop (aperture stop), and the lens unit Gr having a positive refractive power. Moreover, the lens unit Gf is disposed on the object side and the lens unit Gr is disposed on an image side, sandwiching the stop. Furthermore, the optical system has at least one pair of lenses that satisfies conditional expressions 20 (1), (2), and (3).

By at least one pair of lenses satisfying conditional expressions (1), (2), and (3), each of the lens unit Gf and the lens unit Gr has at least one lens of which, a shape is plane-symmetrical with respect to the stop. In other words, in the optical system 25 according to the first embodiment, there is at least one pair of lenses of which, the shape is plane-symmetrical with respect to the stop. Therefore, the optical system has symmetry with respect to the shape of the lens. Accordingly, it is possible to correct favorably, a chromatic aberration of magnification, a 30 distortion, and a coma. Here, the symmetry does not refer only to cases of being completely symmetrical, but also includes cases of being nearly symmetrical.

Moreover, when the numerical aperture on the image side of the optical system is made large, an occurrence of an 35 off-axis aberration is susceptible to be noticeable. However, according to the optical system of the first embodiment, even when the numerical aperture on the image side of the optical system is made large, it becomes easy to suppress the occurrence of the off-axis aberration. As a result, various aberrations are corrected favorably, and a bright and sharp sample image is formed.

An optical system according to a second embodiment will be described below. In the optical system according to the second embodiment, the following conditional expressions 45 (4) and (5) are satisfied:

$$0.1 \le NA, 0.1 \le NA'$$
 (4)

$$-2 < \beta < -0.5$$
 (5)

where.

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system, and

β denotes a projection magnification of the optical system.

By satisfying conditional expressions (4) and (5), it is possible to form a bright and sharp image. Therefore, even if a light intensity of illuminating light or excitation light is small, a bright and sharp image is formed. Moreover, it is 60 possible to make the magnification (projection magnification) of the optical system one time, or close to one time. In this case, by making the numerical aperture on the object side large, it is possible to make the numerical aperture on the image side large (the purpose is served without making the 65 numerical aperture on the image side that small). As a result, it is possible to make the numerical aperture on the image side

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large while maintaining the optical system to be small-sized. Moreover, it is possible to correct various aberrations favorably

For making the numerical aperture on the image side large, it is necessary to make the numerical aperture on the object side large. However, by making so as to exceed a lower limit value of conditional expression (4), the numerical aperture on the object side is not required to be made large. Therefore, small-sizing of the optical system becomes easy. By making so as to exceed a lower limit of conditional expression (5), the magnification of the optical system does not become excessively large. In this case, various aberrations occurred in the lens unit Gf, such as the spherical aberration and a curvature of field, are not enlarged significantly in the lens unit Gr. Therefore, it is preferable from a viewpoint of correcting the aberration favorably to exceed the lower limit value of conditional expression (5).

By making so as to fall below an upper limit value of conditional expression (5), an image that is formed does not become excessively small. Therefore, observation and image pickup of a microstructure of a sample become easy.

Here, it is preferable that the following conditional expression (4') is satisfied instead of conditional expression (4).

Also, it is preferable that the following conditional expression (5') is satisfied instead of conditional expression (5).

$$-1.5 < \beta < -0.75$$
 (5°)

Moreover, it is more preferable that the following conditional expression (5") is satisfied instead of conditional expression (5)

$$-1.2 < \beta < -0.8$$
 (5")

An optical system according to a third embodiment will be described below. The optical system according to the third embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (4) and (6) are satisfied:

$$0.1 \le NA, 0.1 \le NA'$$
 (4)

$$0.5 \le f_{OB}/f_{TL} \le 2$$
 (6)

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

 \mathbf{f}_{OB} denotes a focal length of the lens unit Gf, and

 f_{TL} denotes a focal length of the lens unit Gr.

The optical system according to the third embodiment includes the lens unit Gf having a positive refractive power, the stop (aperture stop), and the lens unit Gr having a positive refractive power. Moreover, the lens unit Gf is disposed on the object side and the lens unit Gr is disposed on the image side, sandwiching the stop. Therefore, in the optical system according to the third embodiment, the refractive power is symmetrical with respect to the stop. In other words, regarding the refractive power, the optical system has symmetry.

Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the coma aberration favorably.

Moreover, when the numerical aperture on the image side of the optical system is made large, an occurrence of an off-axis aberration is susceptible to be noticeable. However, according to the optical system of the third embodiment, even when the numerical aperture on the image side of the optical

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system is made large, it becomes easy to suppress the occurrence of the off-axis aberration. As a result, various aberrations are corrected favorably, and a bright and sharp sample image is formed.

A technical significance of conditional expression (4) is as 5 mentioned above. Moreover, a technical significance of conditional expression (6) is similar to the technical significance of conditional expression (5).

Here, it is preferable that the following conditional expression (6') is satisfied instead of conditional expression (6).

$$0.75 < f_{OB}/f_{TL} < 1.5$$
 (6°)

Moreover, it is more preferable that the following conditional expression (6") is satisfied instead of conditional expression (6).

$$0.8 \le f_{OB}/f_{TL} \le 1.2$$
 (6")

An optical system according to a fourth embodiment will be described below. The optical system according to the fourth embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (7), (8), and (9) are satisfied:

$$30\% \leq MTF_{OB}$$
 (1

$$30\% \leq MFT_{TL}$$
 (8)

$$0 < d_1 / \Sigma d < 0.5 \tag{9}$$

where,

 MTF_{OB} denotes an MTF (Modulation Transfer Function) 30 on an axis in the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

MTF_{TL} denotes an MTF on an axis in the lens unit Gr, and is an MTF with respect to a spatial frequency of fc'/4, where fc denotes a cut-off frequency with respect to the numerical 35 aperture on the object side of the optical system, and

fe' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF $_{OB}$ and MTF $_{TL}$ are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident 40 from the stop side respectively,

 ${\rm d_1}$ denotes a distance on an optical axis from a surface positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit Gr, and

 Σ d denotes a sum total of lens thickness on the optical axis of the overall optical system.

By satisfying conditional expressions (7) and (8), it becomes possible to impart a function equivalent to a function of the objective to the lens unit Gf, and to impart a function 50 equivalent to a function of the tube lens to the lens unit Gr. Accordingly, the optical system becomes suitable for a microscope optical system and an optical system which is suitable for an object of forming a sharp sample image, similar to the microscope optical system. Conditional expression (7-1) or 55 conditional expression (7-1') that will be described later may be satisfied instead of conditional expression (8-1) or conditional expression (8-1') that will be described later may be satisfied instead of conditional expression (8).

By satisfying conditional expression (9), it is possible to dispose the lens unit Gf and the lens unit Gr near the stop (pupil). Here, when the numerical aperture on the image side of the optical system is made large, an occurrence of the off-axis aberration is susceptible to be noticeable. However, 65 according to the optical system of the fourth embodiment, even when the numerical aperture on the image side of the

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optical system is made large, it becomes easy to suppress the occurrence of the off-axis aberration, particularly the occurrence of the coma. As a result, various aberrations are corrected favorably, and a bright and sharp sample image is formed. Any of conditional expressions (9-1), (9-1"), (9-1"), and (9-1"") which will be described later may be satisfied instead of conditional expression (9).

An optical system according to a fifth embodiment will be described below. The optical system according to the fifth embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (7), (8), and (10) are satisfied:

$$30\% \leq MTF_{OB}$$
 (7)

$$30\% \leq MTF_{TL}$$
 (8)

$$0 < d_2 / \Sigma d < 4 \tag{10}$$

where

 MTF_{OB} denotes an MTF on an axis in the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

MTF_{TL} denotes an MTF on an axis in the lens unit Gr, and 25 is an MTF with respect to a spatial frequency of fc'/4, where fc denotes a cut-off frequency with respect to the numerical aperture on the object side of the optical system, and

fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF $_{OB}$ and MTF $_{TL}$ are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident from the stop side respectively,

 ${\rm d}_2$ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr, and

 Σ d denotes a sum total of lens thickness on the optical axis of the overall optical system.

A technical significance of conditional expressions (7) and (8) is as already been explained. Conditional expression (7-1) or conditional expression (7-1') that will be described later may be satisfied instead of conditional expression (7). Moreover, conditional expression (8-1) or conditional expression (8-1') that will be described later may be satisfied instead of conditional expression (8).

By satisfying conditional expression (10), the rear principal point of the lens unit Gf and the front principal point of the lens unit Gr are positioned near the stop (pupil). Here, when the numerical aperture on the image side of the optical system is made large, an occurrence of the off-axis aberration is susceptible to be noticeable. However, according to the optical system of the fifth embodiment, even when the numerical aperture on the image side of the optical system is made large, it becomes easy to suppress the occurrence of the off-axis aberration, particularly the occurrence of the coma. As a result, various aberrations are corrected favorably, and a bright and sharp image is formed. Any of conditional expressions (10-1), (10-1'), (10-1") and (10-1"') that will be described later may be satisfied instead of conditional expression (10).

It is preferable that the optical systems of embodiments from the first embodiment to the fifth embodiment (hereinafter, appropriately called as the optical system according to the present embodiment) have an arrangement of an optical system according to the other embodiments, and satisfy conditional expressions. Accordingly, it is possible to provide an optical system having a large numerical aperture on the image side, and in which, various aberrations are corrected favor-

ably. Moreover, a bright and sharp sample image, in which various aberrations are corrected favorably, is formed.

Moreover, in the optical system according to the present embodiment, it is preferable that the following conditional expression (11) is satisfied:

$$0.05 < \Delta f/Y < 0.05$$
 (11)

where,

 Δf denotes a difference in a focal position on a C-line and a focal position on an F-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side, and

Y denotes the maximum image height in an overall optical system.

In the optical system according to the present embodiment, 15 the optical system has symmetry with regard to a shape of lens or a refractive power of lens, or both. Therefore, the chromatic aberration of magnification, the distortion, and the coma occur in opposite directions in the lens unit Gf and the lens unit Gr. Therefore, by rendering the lens unit Gf and the lens 20 unit Gr in a combined state, it is possible to cancel an aberration occurred in the lens unit Gf, in the lens unit Gr.

However, a longitudinal chromatic aberration occurs in the same direction in both the lens unit Gf and the lens unit Gr. For this reason, in the state of the lens unit Gf and the lens unit 25 optical system, Gr combined, the aberration occurred in the lens unit Gf cannot be cancelled in the lens unit Gr. Therefore, the longitudinal chromatic aberration is required to be corrected only in the lens unit Gr. The longitudinal chromatic aberration is also required to be corrected only in the lens unit Gf.

By making so as to fall below an upper limit value of conditional expression (11) or by making so as to exceed a lower limit value of conditional expression (11), correction of the longitudinal chromatic aberration in the overall optical system becomes easy.

Moreover, it is preferable that the optical system according to the present embodiment has at least two pairs of lenses.

Regarding the shape of lens, symmetry of the optical system improves further. Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the 40 coma even more favorably.

Moreover, it is preferable that the optical system according to the present embodiment has at least three pairs of lenses.

Regarding the shape of lens, the symmetry of the optical system improves further. Therefore, it is possible to correct 45 the chromatic aberration of magnification, the distortion, and the coma favorably.

Moreover, in the optical system according to the present embodiment, it is preferable that the following conditional expression (12) is satisfied:

$$-10^{\circ} < \theta_{o} < 10^{\circ} \tag{12}$$

 θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object 55

By making so as to exceed a lower limit value of conditional expression (12), or by making so as to fall below an upper limit value of conditional expression (12), it is possible to impart telecentricity on the object side, in the optical sys- 60 tem. Accordingly, it is possible to suppress the fluctuation in magnification corresponding to a fluctuation in an object (photographic subject) distance. For instance, in a case of carrying out dimensional measurement by using the optical system according to the present embodiment, even when the 65 object (substance to be tested) has concavity and convexity in the optical axial direction, since a magnification for a concave

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portion and a magnification for a convex portion being same, an accurate measurement is possible.

In the optical system according to the present embodiment, it is preferable that each lens in the pair of lenses disposed at 5 a position nearest from the stop is a positive lens. Moreover, it is preferable that each lens in the pair of lenses disposed at a position second nearest from the stop is a negative lens.

An optical system according to a sixth embodiment will be described below. The optical system according to the sixth embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (9-1), and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_1 / \Sigma d < 0.2$$
 (9-1)

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where.

NA denotes a numerical aperture on the object side of the

NA' denotes a numerical aperture on an image side of the optical system,

 β denotes a projection magnification of the optical system,

d₁ denotes a distance on an optical axis from a surface 30 positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit Gr,

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

€d denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

An upper limit of a resolution on the object side is determined by the NA, and an upper limit of a resolving power on the image side is determined by the NA' and a pixel pitch of an image pickup element. By including in order from the object side, the lens unit Gf having a positive refractive power, the stop, and the lens unit Gr having a positive refractive power, as well as conditional expression (4-1) and (5) are satisfied simultaneously, it is possible to make a balance of the resolution on the object side and the resolving power on the image side favorable. Moreover, it is possible to correct various aberrations favorably, and to improve an imaging performance to the maximum limit, as well as to form an optical system of a small size. Particularly, the optical system according to the sixth embodiment is an optical system ideal for an image pickup element with the pixel pitch from about one time to three times of a visual light wavelength.

Moreover, by satisfying conditional expressions (4-1) and (5) simultaneously, even when the light intensity of the illuminating light and the excitation light is small, it is possible to form a bright and sharp image while maintaining the optical system to be small-sized.

For making the numerical aperture on the image side large, it is necessary to make the numerical aperture on the object side large. However, by making so as to exceed a lower limit value of conditional expression (5), the numerical aperture on the object side is not required to be made large. Therefore,

small-sizing of the optical system becomes easy. Moreover, by making so as to exceed the lower limit value of conditional expression (5), the magnification of the optical system does not become excessively large. In this case, various aberrations occurred in the lens unit Gf, such as the spherical aberration and the curvature of field, are not enlarged significantly in the lens unit Gr. Therefore, it is preferable from a viewpoint of correcting the aberration favorably to exceed the lower limit value of conditional expression (5).

By making so as to fall below an upper limit value of 10 conditional expression (5), an image that is formed does not become excessively small. Therefore, observation and image pickup of a microstructure of a sample become easy.

Here, it is preferable that the following conditional expression (4-1') is satisfied instead of conditional expression (4-1). 15

Moreover, it is preferable that the abovementioned conditional expression (4') is satisfied instead of conditional expression (4-1).

It is preferable that the abovementioned conditional expression (5') is satisfied instead of conditional expression (5). Moreover, it is more preferable that the abovementioned conditional expression (5") is satisfied instead of conditional expression (5).

By satisfying conditional expressions (9-1) and (13), regarding a lens arrangement in the lens unit Gf and a lens arrangement in the lens unit Gf, it is possible to dispose the lens unit Gf and the lens unit Gr near the stop while imparting symmetry with respect to the stop. When the numerical aperture on the image side of the optical system is made large, the occurrence of the off-axis aberration, particularly the occurrence of the coma becomes noticeable, but by making such an arrangement, it becomes easier to suppress the occurrence of such aberration. Here, \mathbf{d}_1 is a distance between the two surfaces, and the two surfaces in this case are both lens surfaces.

Here, it is preferable that the following conditional expression (9-1') is satisfied instead of conditional expression (9-1).

$$0 < d_1 / \Sigma d < 0.15$$
 (9-1')

Moreover, it is more preferable that the following conditional expression (9-1") is satisfied instead of conditional expression (9-1).

$$0 < d_1/\Sigma d < 0.07$$
 (9-1")

Furthermore, it is even more preferable that the following conditional expression (9-1") is satisfied instead of conditional expression (9-1).

$$0 < d_1/\Sigma d < 0.03$$
 (9-1''')

By satisfying conditional expression (13), it is possible to correct the off-axis aberrations such as the chromatic aberration and the coma favorably while maintaining the correction of the longitudinal chromatic aberration to a favorable state. In the optical system according to the sixth embodiment, by satisfying conditional expressions (4-1) and (5), it becomes possible to make the numerical aperture on the image side large with respect to the numerical aperture on the object side, or to make an arrangement such that the numerical aperture on the image side does not become excessively small with respect to the numerical aperture on the object side. Accordingly, it is made possible to form a brighter and sharper image, but at the same time, it is necessary to suppress the occurrence of the longitudinal chromatic aberration of the overall optical system to be small.

The optical system according to the sixth embodiment includes in order from the object side, the lens unit Gf having

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a positive refractive power, the stop, and the lens unit Gr having a positive refractive power, and is an optical system which satisfies conditional expression (5), or in other words, an optical system with an imaging magnification to be one time or close to one time. In such optical system, by making so as to fall below an upper limit value of conditional expression (13) or by making so as to exceed a lower limit value of conditional expression (13), it is possible to suppress the occurrence of the longitudinal chromatic aberration in the lens unit Gr. By enabling to suppress the occurrence of the longitudinal chromatic aberration in the lens unit Gr, it is possible to make the excessive correction of the longitudinal chromatic aberration in the lens unit Gf unnecessary. Therefore, regarding a lens arrangement in the lens unit Gf and a lens arrangement in the lens unit Gr, it is possible to impart symmetry with respect to the stop. By making the numerical aperture of the optical system large, the occurrence of aberrations such as the coma and the chromatic aberration of magnification becomes noticeable, but since the lens arrange-20 ment in the lens unit Gf and the lens arrangement in the lens unit Gr have symmetry with respect to the stop, it becomes possible to correct these aberrations favorably. Here, the symmetry does not refer only to cases of being completely symmetrical, but also includes cases of being nearly symmetrical.

Here, it is preferable that the following conditional expression (13') is satisfied instead of conditional expression (13).

$$-15 < \Delta f_{cd} / \epsilon d < 15 \tag{13'}$$

Moreover, it is more preferable that the following condi-30 tional expression (13") is satisfied instead of conditional expression (13).

$$-12 < \Delta f_{cd} < d < 12 \tag{13"}$$

arrangement, it becomes easier to suppress the occurrence of such aberration. Here, d_1 is a distance between the two surfaces, and the two surfaces in this case are both lens surfaces.

Furthermore, it is even more preferable that the following conditional expression (13") is satisfied instead of conditional expression (13).

$$-7 < \Delta f_{cd} / \epsilon d < 7 \tag{13}$$

An optical system according to a seventh embodiment will be described below. The optical system according to the seventh embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (10-1), and (13) are satisfied:

$$0.08 < NA, 0.08 < NA'$$
 (4-1)

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_2 / \Sigma d < 2$$
 (10-1)

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

β denotes a projection magnification of the optical system, d₂ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr.

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

€d denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

A technical significance of conditional expressions (4-1), 5 (5), and (13) is as already been described above.

Moreover, by satisfying conditional expressions (10-1) and (13), regarding a lens arrangement in the lens unit Gf and a lens arrangement in the lens unit Gr, it is possible to position a principal point of the lens unit Gf and a principal point of the lens unit Gr near the stop while imparting symmetry with respect to the stop. When the numerical aperture on the image side of the optical system is made large, the occurrence of the off-axis aberration, particularly the occurrence of the coma becomes noticeable, but by making such an arrangement, it 15 becomes easier to suppress the occurrence of the aberration.

Here, it is preferable that the following conditional expression (10-1') is satisfied instead of conditional expression (10-1).

$$0 < d_2 / \Sigma d < 1.5$$
 (10-1') 20 stop.

Moreover, it is more preferable that the following conditional expression (10-1") is satisfied instead of conditional expression (10-1).

$$0 < d_2 / \Sigma d < 1$$
 (10-1") 25

Furthermore, it is even more preferable that the following conditional expression (10-1") is satisfied instead of conditional expression (10-1).

$$0 < d_2 / \Sigma d < 0.7$$
 (10-1''') 30

It is all the more preferable to satisfy the following conditional expression (10-1"") instead of conditional expression (10-1)

It is preferable that the optical system according to the sixth embodiment and the optical system according to the seventh embodiment (hereinafter, called appropriately as an 'optical system according to the present embodiment') have an arrangement of an optical system according to the other embodiments, and satisfy conditional expressions. Accordingly, it is possible to provide an optical system with a large numerical aperture on the image side, and in which, various aberrations are corrected favorably. Moreover, a bright and sharp sample image, in which various aberrations are corrected favorably, is formed.

In the optical system according to the present embodiment, it is preferable that the following conditional expressions (7-1) and (8-1) are satisfied:

$$40\% \le MTF_{OB}$$
 (7-1)

$$40\% \leq MTF_{TL}$$
 (8-1)

where,

 MTF_{OB} denotes an MTF on an axis in the lens unit Gf, and 55 is an MTF with respect to a spatial frequency of fc/4,

MTF_{TL} denotes an MTF on an axis in the lens unit Gr, and is an MTF with respect to a spatial frequency of fc'/4, where fc denotes a cut-off frequency with respect to the numerical

fc denotes a cut-off frequency with respect to the numerical aperture on the object side of the optical system, and

fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF $_{OB}$ and MTF $_{TL}$ are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident from the stop side, respectively.

By satisfying conditional expressions (7-1) and (8-1), it becomes possible to impart a function equivalent to a function

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of the objective to the lens unit Gf, and to impart a function equivalent to a function of the tube lens to the lens unit Gr. Accordingly, in an optical arrangement in which, light emerged from the lens unit Gf becomes a substantially parallel light beam, it is possible to correct a longitudinal aberration favorably. Therefore, in the optical system which satisfies conditional expression (5), by further satisfying conditional expressions (7-1) and (8-1), regarding the arrangement of the lens unit Gf and the arrangement of the lens unit Gr, it becomes easy to impart symmetry with respect to the stop. As a result, it is possible to suppress an off-axis distortion, the chromatic aberration of magnification, and the coma favorably.

Furthermore, since a light beam passing through the stop becomes substantially parallel, it becomes possible to insert an optical element such as a phase plate and a polarization plate being necessary for various observation techniques (such as phase-contrast microscopy, polarization microscopy, and differential interference contrast microscopy), near the stop.

Here, it is preferable that the following conditional expression (7-1') is satisfied instead of conditional expression (7-1).

$$50\% \leq MTF_{OB} \tag{7-1'}$$

Moreover, it is preferable that the following conditional expression (8-1') is satisfied instead of conditional expression (8-1).

$$50\% \leq MTF_{TL}$$
 (8-1')

In the optical system according to the present embodiment, it is preferable that the following conditional expression (6) is satisfied:

$$0.5 \le f_{OB}/f_{TL} \le 2$$
 (6)

wher

 ${\bf f}_{OB}$ denotes a focal length of the lens unit Gf, and ${\bf f}_{TL}$ denotes a focal length of the lens unit Gr.

The optical system according to the present embodiment is an optical system which satisfies conditional expression (5), or in other words, is an optical system having a projection magnification which is one time or close to one time. In the optical system having a projection magnification which is one time or close to one time, by satisfying conditional expression (6), regarding an arrangement of the lens unit Gf and an arrangement of the lens unit Gr, it becomes possible to impart symmetry with respect to the stop. When the numerical aperture on the image side of the optical system is made large, the occurrence of off-axis aberrations such as the chromatic aberration of magnification and the coma becomes noticeable. However, since the arrangement of the lens unit Gf and the arrangement of the lens unit Gr have symmetry with respect to the stop, it becomes possible to correct these aberrations favorably.

It is preferable that the aforementioned conditional expression (6') is satisfied instead of conditional expression (6). Moreover, it is more preferable that the aforementioned conditional expression (6") is satisfied instead of conditional expression (6).

In the optical system according to the present embodiment, it is preferable that the following conditional expression (14) is satisfied:

$$0.7 < d_{SHOB}/d_{SHTL} < 1.3$$
 (14)

where

 ${\rm d}_{SHOB}$ denotes a distance on the optical axis from a front principal point of the lens unit Gf up to the stop, and

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 d_{SHTL} denotes a distance on the optical axis from the stop up to a rear principal point of the lens unit Gr.

A technical significance of conditional expression (14) is same as the technical significance of conditional expression

It is preferable that the following conditional expression (14') is satisfied instead of conditional expression (14).

$$0.8 < d_{SHOB}/d_{SHTL} < 1.2$$
 (14')

It is more preferable that the following conditional expression (14") is satisfied instead of conditional expression (14).

$$0.9 < d_{SHOB}/d_{SHTL} < 1.1$$
 (14")

Moreover, in the optical system according to the present 15 embodiment, it is preferable that a positive lens Lf1 is disposed nearest to the image in the lens unit Gf.

By making such an arrangement, since it becomes possible to position a principal point of the lens unit Gf at the stop side conjugate length (distance from the object up to the image). Moreover, when the numerical aperture on the image side of the optical system is made large, the occurrence of the offaxis aberration, particularly the occurrence of the coma becomes noticeable. However, by positioning the principal 25 point of the lens unit Gf near the stop (pupil), it becomes easier to suppress the occurrence of the off-axis aberration.

Moreover, in the optical system according to the present embodiment, it is preferable that a positive lens Lr1 is disposed nearest to the object in the lens unit Gr.

By making such an arrangement, since it becomes possible to position a principal point of the lens unit Gr at the stop side (or near the stop), it becomes advantageous for shortening the conjugate length. Moreover, when the numerical aperture on the image side of the optical system is made large, the occur- 35 rence of the off-axis aberration, particularly the occurrence of the coma becomes noticeable. However, by positioning the principal point of the lens unit Gr near the stop (pupil), it becomes easier to suppress the occurrence of the off-axis aberration.

Moreover, in the optical system according to the present embodiment, it is preferable that a negative lens Lf2 is disposed on the object side of the positive lens Lf1 such that, the negative lens Lf2 is adjacent to the positive lens Lf1.

By the negative lens Lf2, it is possible to correct favorably 45 a chromatic aberration occurring in the positive lens Lf1. Besides, since the negative lens Lf2 is disposed to be adjacent to the positive lens Lf1, it is possible to suppress the occurrence of the chromatic aberration of magnification in the lens unit Gf. As a result, it is possible to correct the chromatic 50 aberration of magnification of the overall optical system favorably.

In the optical system according to the present embodiment, it is preferable that a negative lens Lr2 is disposed on the image side of the positive lens Lr1 such that, the negative lens 55 Lr2 is adjacent to the positive lens Lr1.

By the negative lens Lr2, it is possible to correct favorably the chromatic aberration occurring in the positive lens Lr1. Besides, since the negative lens Lr2 is disposed to be adjacent to the positive lens Lr1, it is possible to suppress the occur- 60 rence of the chromatic aberration of magnification in the lens unit Gr. As a result, it is possible to correct the chromatic aberration of magnification of the overall optical system favorably.

Moreover, in the optical system according to the present 65 embodiment, it is preferable that an object-side surface of the negative lens Lf2 is concave toward the object side.

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By making such an arrangement, since it is possible to make large an angle of incidence of an off-axis light beam incident on the negative lens Lf2, it is possible to shorten the conjugate length of the optical system while maintaining a wide range of observation (an actual field of view).

Moreover, in the optical system according to the present embodiment, it is preferable that an image-side surface of the negative lens Lr2 is concave toward the image side.

By making such an arrangement, since it is possible to make large an angle of emergence of an off-axis light beam emerging from the negative lens Lr2, it is possible to shorten the conjugate length of the optical system while maintaining a wide observation range.

Moreover, in the optical system according to the present embodiment, it is preferable that the lens unit Gf includes a lens Lfe which is disposed nearest to the object, and a shape of at least one lens surface of the lens Lfe is a shape having an inflection point.

By letting the shape of the lens surface near the object side (or near the stop), it becomes advantageous for shortening a 20 to be a surface shape having the inflection point, and by letting a refractive power at a periphery to differ from a refractive power at a center, it becomes possible to reduce an angle of emergence of the off-axis light beam with respect to the object plane while maintaining a principal plane of the lens unit Gf at an optimum position. Moreover, since a position through which, the off-axis ray passes through a lens surface near the object becomes high, by providing the point of inflection to that surface, and letting the refractive power at the periphery to differ from the refractive power at the center, it is possible to correct favorably the off-axis aberration such as the curvature of field and an astigmatism.

> Moreover, in the optical system according to the present embodiment, it is preferable that the lens unit Gr includes a lens Lre which is disposed nearest to the image, and a shape of at least one lens surface of the lens Lre is a shape having an inflection point.

> By letting the shape of the lens surface near the image side to be a surface shape having the inflection point, and by letting a refractive power at a periphery to differ from a refractive power at a center, it becomes possible to reduce an angle of incidence of the off-axis light beam with respect to the image plane while maintaining a principal plane of the lens unit Gr at an optimum position. Moreover, since a position through which, the off-axis ray passes through a lens surface near the image becomes high, by providing the point of inflection to that surface, and letting the refractive power at the periphery to differ from the refractive power at the center, it is possible to correct favorably the off-axis aberration such as the curvature of field and the astigmatism.

> Moreover, in the optical system according to the present embodiment, it is preferable that the lens Lfe has a negative refractive power.

> By making such an arrangement, since it becomes possible to position the principal plane of the lens unit Gf at the stop side, it becomes advantageous for shortening the conjugate length. Moreover, by positioning the principal plane of the lens unit Gf near the stop (pupil), even when the numerical aperture on the image side of the optical system is made large, it is possible to suppress the occurrence of the off-axis aberration, particularly the occurrence of the coma.

> Moreover, in the optical system according to the present embodiment, it is preferable that the lens Lre has a negative refractive power.

By making such an arrangement, since it becomes possible to position the principal plane of the lens unit Gr at the stop side, it becomes advantageous for shortening the conjugate length. Moreover, by positioning the principal plane of the

lens unit Gr near the stop (pupil), even when the numerical aperture on the image side of the optical system is made large, it is possible to suppress the occurrence of the off-axis aberration, and particularly the occurrence of the coma.

Moreover, in the optical system according to the embodiment, it is preferable that the loptical system includes at least one pair of lenses which satisfies the following conditional expressions (1), (2), and (3), and one lens in the pair of lenses is included in the lens unit Gf, and the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OB}/r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OBr} / r_{TLf} < -0.9$$
 (2)

$$-0.1 < (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) < 0.1$$
 (3)

where.

 r_{OBf} denotes a paraxial radius of curvature of an object-side surface of the one lens in the pair of lenses,

 r_{OBr} denotes a paraxial radius of curvature of an image-side surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 r_{TLr} denotes a paraxial radius of curvature of an image-side 25 surface of the other lens in the pair of lenses,

 \mathbf{d}_{OB} denotes a thickness on the optical axis of the one lens in the pair of lenses, and

 d_{TL} denotes a thickness on the optical axis of the other lens in the pair of lenses.

The technical significance of conditional expressions (1), (2), and (3) is as aforementioned.

Moreover, it is preferable that the optical system according to the present embodiment has at least two pairs of lenses.

Regarding the shape of lens, symmetry of the optical system improves further. Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the coma even more favorably.

Moreover, it is preferable that the optical system according to the present embodiment has at least three pairs of lenses.

Regarding the shape of lens, the symmetry of the optical system improves further. Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the coma favorably.

Moreover, in the optical system according to the present embodiment, it is preferable that the following conditional expression (12-1) is satisfied:

$$-10^{\circ} < \theta_{o} < 30^{\circ}$$
 (12-1)

where.

 θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object side.

By making so as to exceed a lower limit value of conditional expression (12-1), or making so as to fall below an 55 upper limit value of conditional expression (12-1), it is possible to impart telecentricity on the object side, in the optical system. Accordingly, it is possible to suppress the fluctuation in magnification corresponding to a fluctuation in the object (photographic subject) distance. For instance, in a case of 60 carrying out dimensional measurement by using the optical system of the present embodiment, even when the object (substance to be tested) has concavity and convexity in the optical axial direction, since it is possible to make a difference in a magnification for a concave portion and a magnification 65 for a convex portion small, an accurate measurement is possible.

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Moreover, in a case of seeking even higher telecentricity in the optical system, in the optical system according to the present embodiment, it is preferable that the following conditional expression (12-1') is satisfied.

$$-5^{\circ} < \theta_{o} < 5^{\circ} \tag{12-1'}$$

Moreover, in a case of seeking further small-sizing (short-ening overall length of the optical system, and making a diameter fine) in the optical system, in the zoom lens of the present embodiment, it is preferable that the following conditional expression (12-1") is satisfied.

$$15^{\circ} < \theta_{o} < 30^{\circ}$$
 (12-1")

A focal length of a tube lens used in a conventional microscope is approximately 10 times of a focal length of a microscope objective. Therefore, the numerical aperture (NA') on the image side becomes small to about 0.08. However, in the aforementioned embodiments from the first embodiment to the seventh embodiment, it is possible to realize an optical system in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably.

Moreover, an optical instrument (such as a microscope) of the present embodiment includes the aforementioned optical system, and an image pickup element.

According to the optical instrument of the present embodiment, it is possible to realize an optical instrument in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably. Moreover, a bright and sharp sample image in which, various aberrations have been corrected, is formed.

An optical system according to an eighth embodiment, an optical system according to a ninth embodiment, and an optical system according to a tenth embodiment (hereinafter, appropriately called as an 'optical system according to the present embodiment') will be described below. Moreover, a marginal ray is a light rays emerged from an object point on the optical axis, and passing through a peripheral portion of an entrance pupil of the optical system. Here, in the following description, in a case in which, the marginal ray has emerged from an object point on the optical axis, the marginal ray will be let to be an axial marginal ray, and in a case in which, the marginal ray has emerged from an off-axis object point, the marginal ray will be let to be an off-axis marginal ray. Moreover, the optical system according to the present embodiment is an optical system presupposing that an object is at a finite distance from the optical system (finite correction optical system).

Moreover, in an image pickup apparatus using the optical system according to the present embodiment, it is possible to let an image photographed to be subjected to digital zooming, and make a magnified display thereof. Therefore, the optical systems of these embodiments have a high resolution as various aberrations are corrected favorably, and are capable of forming an image over a wide observation range. In the optical systems of these embodiments, since a longitudinal chromatic aberration and an off-axis chromatic aberration in particular, has been corrected favorably, by combining with an image pickup element having a small pixel pitch, a magnified image with a high resolution is achieved even in a case in which, the image captured is magnified by digital zooming.

The optical system according to the eighth embodiment is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and comprises in order from an object side,

a first lens unit having a positive refractive power, which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens 10 which is disposed nearest to an image, and

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

The following conditional expressions (15), (16), (19), and 15 (20) are satisfied:

$$\beta \leq -1.1 \tag{15}$$

$$1.0 < WD/BF \tag{19}$$

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 4.0$$
 (20)

 β denotes an imaging magnification of the optical system, NA denotes a numerical aperture on the object side of the optical system,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens,

BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the image,

Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

The optical system according to the ninth embodiment is 35 an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and comprises in order 40 optical system, from an object side,

- a first lens unit which includes a plurality of lenses,
- a stop, and
- a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens 50 which is disposed nearest to an image, and

the following conditional expressions (16), (21), (23-1), and (24-1) are satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

$$0.6 \le L_I/D_{oi}$$
 (23-1)

$$0.015 < 1/v d_{min} - 1/v d_{max} \tag{24-1}$$

NA denotes a numerical aperture on the object side of the optical system,

 D_{max} denotes a maximum distance from among distances 65 on an optical axis of adjacent lenses in the optical system,

 ϕ_s denotes a diameter of the stop,

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L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side surface of the second image-side lens,

 D_{oi} denotes a distance on the optical axis from the object to the image,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the optical system.

The optical system according to the tenth embodiment is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and for which, a pitch of pixels is not more than 5.0 µm, and comprises in order from an object side,

- a first lens unit which includes a plurality of lenses,
- a stop, and

a second lens unit which includes a plurality of lenses,

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the following conditional expressions (16), (18), and (25) are satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) / \epsilon_d < 30$$
(18)

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

NA denotes a numerical aperture on the object side of the

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G_1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object (16) 55 side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system,

D_{os} denotes a distance on the optical axis from the object up to the stop, and

D_{at} denotes a distance on the optical axis from the object up to the image, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

Each of the optical system according to the eighth embodiment, the optical system according to the ninth embodiment, and the optical system according to the tenth embodiment is an optical system that forms an optical image on the image pickup element. Here, the image pickup element includes a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively.

In the optical system according to the eighth embodiment, it is preferable that the following conditional expression (15) is satisfied:

$$\beta \leq -1.1 \tag{15}$$

where,

 β denotes an imaging magnification of the optical system. When the numerical aperture on the object side of the optical system is enlarged (the numerical aperture is made large), and a working distance is made long to a certain extent, since a height of an axial marginal ray incident on the optical system (lens positioned nearest to the object) becomes high, the axial aberration is susceptible to occur. Therefore, by satisfying conditional expression (15), since it is possible to suppress the height of the axial marginal ray and the off-axis marginal ray incident on the optical system, it is possible to suppress further the occurrence of the axial aberration and the off-axis aberration.

Moreover, in the optical system according to the ninth ³⁰ embodiment, it is preferable that the following conditional expression (15-1) is satisfied:

where,

β denotes an imaging magnification of the optical system. By satisfying conditional expression (15-1), the optical system becomes a magnifying optical system. Accordingly, it is possible to realize more detailed observation.

Moreover, in the optical system according to the tenth embodiment, it is preferable that the following conditional expression (15-2) is satisfied:

$$-1.1 \le \beta \le -0.9$$
 (15-2)

where.

 β denotes an imaging magnification of the optical system. Moreover, in the optical system according to the present embodiment, it is preferable that the following conditional expression (16) is satisfied:

where,

NA denotes a numerical aperture on the object side of the optical system.

By satisfying conditional expression (16), it is possible to realize an optical system and an image pickup apparatus having a high resolution.

Moreover, it is preferable that the optical system according to the present embodiment is an optical system which is used 60 in a microscope.

It is preferable that the optical system according to the present embodiment includes in order from an object side, a first lens unit which includes a plurality of lenses, a stop, and a second lens unit which includes a plurality of lenses, and that the lens units which form the optical system include the first lens unit and the second lens unit. It is preferable that the

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stop is an aperture stop. It is possible that the lens units which form the optical system consist of the first lens unit and the second lens unit.

Moreover, in the optical system according to the present embodiment, it is preferable that the first lens unit includes a first object-side lens which is disposed nearest to an object. Moreover, it is preferable that the first lens unit includes a first image-side lens which his disposed nearest to the image. It is preferable that the second lens unit includes a second object-side lens which is disposed nearest to the object. Moreover, it is preferable that the second lens unit includes a second image-side lens which is disposed nearest to the image.

In the optical system according to the present embodiment, it is preferable that the following conditional expression (17) is satisfied:

$$L_{TL}/2Y < 15$$
 (17)

where,

 $L_{\it TL}$ denotes a distance on an optical axis from an object-side surface of the first object-side lens up to an image, and

Y denotes a maximum image height in an overall optical system.

By satisfying conditional expression (17), it is possible to make the optical system and the overall image pickup apparatus small.

Moreover, in the optical system according to the present embodiment, it is preferable that the lens units which form the optical system includes the first lens unit and the second lens unit, and the pitch of pixels is not more than 5.0 μ m, and the following conditional expression (18) is satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dc} \times \beta_{G2C})^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC})$$

$$f_{G2C}))) / \epsilon_d < 30$$
(18)

where

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 $\Delta D_{G1,dC}$ denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens unit, and

 ϵ_d denotes an Airy disc radius for the d-line which is determined by the numerical aperture on the image side of the optical system, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

Conditional expression (18) is a conditional expression related to a balance between a correction function of the longitudinal chromatic aberration of the first lens unit and a correction function of the longitudinal chromatic aberration of the second lens unit, and is a conditional expression related to a difference in an image position on the d-line and an image position on the C-line. By the first lens unit and the second

lens unit satisfying conditional expression (18), it is possible to correct the longitudinal chromatic aberration of the overall optical system favorably. Moreover, by the longitudinal chromatic aberration being corrected favorably, it is possible to improve the resolution of the optical system. As a result, it is possible to observe a microscopic structure of a sample with a high resolution, even in color.

Particularly, in the optical system which satisfies conditional expressions (15-2) and (16), or in other words, in the optical system with a large numerical aperture on the image side, for achieving high resolution, it is necessary that the longitudinal chromatic aberration has been corrected more favorably, and by satisfying conditional expression (18), the abovementioned effect is achieved.

At the time of calculating ϵ_d , the optical system is assumed 15 to be an ideal optical system. When the optical system is assumed to be an ideal optical system, the shape of the Airy disc becomes circular. Since a size of the radius of the Airy disc is determined by the numerical aperture on the image side, it is possible to calculate the radius of the Airy disc 20 uniquely.

Moreover, it is preferable to let the pitch of the pixels to be not less than $0.5~\mu m$.

Here, it is preferable that the following conditional expression (18') is satisfied instead of conditional expression (18). 25

$$-21 < (\Delta D_{G2dC} + (\Delta D_{G1dc} \times \beta_{G2C})^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC})$$

$$f_{G2C})))/\epsilon_d < 21$$
(18)

Moreover, it is more preferable that the following conditional expression (18") is satisfied instead of conditional expression (18).

negative lens, and negative lens, and (20) is satisfied:

$$-15 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{GC}))) / \epsilon_d < 15$$

$$(18")$$

Furthermore, it is even more preferable that the following conditional expression (18") is satisfied instead of conditional expression (18).

$$-9 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2)/(1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C})))/\epsilon_d < 9$$

$$(18"')$$

In the optical system according to the eighth embodiment 40 and the optical system according to the tenth embodiment, it is preferable that the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from an image-50 side surface of the second image-side lens up to an image.

It is preferable to dispose the lens unit having a positive refractive power on the object side of the stop. Accordingly, it is possible to position the principal point on the object side. Therefore, it is possible to shorten the overall length of the 55 optical system while maintaining the state in which, the longitudinal chromatic aberration has been corrected favorably.

In conditional expression (19), WD is the distance on the optical axis from the object up to the object-side surface of the first object-side lens, but will be called as a working distance 60 in the present specification. Moreover, BF is the distance on the optical axis from the image-side surface of the second image-side lens up to the image, but will be called as a back focus in the present specification. Accordingly, conditional expression (19) can be said to be a conditional expression 65 which regulates an appropriate ratio of the working distance and the back focus.

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By making so as not to fall below a lower limit value of conditional expression (19), it is possible to prevent the back focus from becoming excessively long. When such an arrangement is made, since it is possible to make a distance from the stop up to the image short, it is possible to make a height of a principal ray higher on the image side than at the stop. As a result, since it is possible to carry out an aberration correction in a state in which, the height of the principal ray has become high in the second lens unit, it is possible to correct favorably the chromatic aberration of magnification in particular.

Here, it is preferable that the following conditional expression (19') is satisfied instead of conditional expression (19).

$$1.2 < WD/BF < 50.0$$
 (19')

Moreover, it is more preferable that the following conditional expression (19") is satisfied instead of conditional expression (19).

$$1.4 < WD/BF < 35.0$$
 (19")

Furthermore, it is even more preferable that the following conditional expression (19") is satisfied instead of conditional expression (19).

$$2.0 < WD/BF < 17.5$$
 (19")

In the optical system according to the eighth embodiment, it is preferable that the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and that the following conditional expression (20) is satisfied:

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 4.0$$
 (20)

where.

WD denotes a distance on an optical axis from the object up 35 to the object-side surface of the first object-side lens,

NA denotes a numerical aperture on the object side of the optical system,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

By disposing the positive lens and the negative lens in the first lens unit, it is possible to correct the longitudinal chromatic aberration favorably. At this time, by disposing the positive lens on the object side of the negative lens, it is possible to correct the longitudinal chromatic aberration 45 more favorably.

By satisfying conditional expression (20), it is possible to correct the chromatic aberration more favorably. The stop being the aperture stop, it is possible to let the stop to be a stop that determines the NA.

By making so as not to fall below a lower limit value of conditional expression (20), it is possible to suppress a predetermined refraction effect in the first lens unit from becoming excessively small. Therefore, since it is possible to position a principal point sufficiently on the object side, it is possible to shorten the overall length of the optical system. The predetermined refraction is an effect of making a light ray refract in order to bring closer to the optical axis. Larger the predetermined refraction effect, the light ray is refracted in a direction of coming closer to the optical axis. For instance, larger the predetermined refraction effect, convergence becomes stronger in the convergence effect, and divergence becomes weaker in the divergence effect.

By making so as not to exceed an upper limit value of conditional expression (20) is not exceeded, it is possible to prevent the predetermined refraction effect in the first lens unit from becoming excessively large. Accordingly, it is possible to correct the longitudinal chromatic aberration due to

the axial marginal ray and the off-axis chromatic aberration at the maximum image height favorably and in a balanced manner. Even in a range of satisfying conditional expression (16), it is possible to correct the longitudinal chromatic aberration and the off-axis chromatic aberration favorably and in a balanced manner.

By satisfying conditional expressions (16), (19), and (20), it is possible to realize enlargement of the numerical aperture on the object side, shortening of the overall length of the optical system, and favorable correction of the chromatic aberration, while securing appropriately a thickness of optical components forming the optical system.

Here, it is preferable that the following conditional expression (20') is satisfied instead of conditional expression (20).

$$0.63 < 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s < 3.70$$
 (20')

Moreover, it is more preferable that the following conditional expression (20") is satisfied instead of conditional expression (20).

$$0.78 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 3.50$$
 (20")

Furthermore, it is even more preferable that the following conditional expression (20") is satisfied instead of conditional expression (20).

$$0.98 < 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obi})/\phi_s < 3.15$$
 (20")

In the optical system according to the tenth embodiment, it is preferable that the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and the following conditional expression (20-1) is satisfied:

$$1.0 < 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obi})/\phi_s < 5.0$$
 (20-1)

where,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens,

NA denotes a numerical aperture on the object side of the optical system,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (20-1), it is possible to realize simultaneously, enlargement of the numerical aperture on the object side, shortening of the overall length of the optical system, and favorable correction of the chromatic aberration, while securing appropriately a thickness of optical components forming the optical system.

A technical significance of conditional expression (20-1) is same as the technical significance of conditional expression (20).

BY satisfying conditional expressions (16) and (20-1), and conditional expression (25) that will be described later, it is possible to correct the chromatic aberration more favorably while securing the required lens thickness, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (20-1') is satisfied instead of conditional expression (20-1).

$$1.33 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 4.75$$
 (20-1')

Moreover, it is more preferable that the following conditional expression (20-1") is satisfied instead of conditional expression (20-1).

Furthermore, it is even more preferable that the following conditional expression (20-1") is satisfied instead of conditional expression (20-1).

$$2.37 < 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s < 4.29$$
 (20-1"')

In the optical system according to the present embodiment, it is preferable that the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where

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 ${\rm D}_{max}$ denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (21), it is possible to correct a chromatic coma more favorably.

By making so as not to fall below a lower limit value of conditional expression (21), it is possible to reduce deterioration of aberration due to a manufacturing error. For instance, decentering of a lens at the time of lens assembling is an example of the manufacturing error.

By making so as not to exceed an upper limit value of conditional expression (21), even in a case in which, the numerical aperture on the object side is large, it is possible to suppress the height of the off-axis marginal ray with respect to the height of the axial marginal ray from changing substantially between the lenses. For instance, let two adjacent lenses be a lens L_A and a lens L_B . The height of the off-axis marginal ray for the lens L_A and the height of the off-axis marginal ray for the lens L_B differ. However, by making a distance between the lens L_A and the lens L_B appropriate, it is possible to reduce the difference between the height of the off-axis marginal ray for the lens L₄ and the height of the off-axis marginal ray for the lens L_B . As a result, since it is possible to reduce a difference between the chromatic aberration for an off-axis light beam incident on the lens L_A and the chromatic aberration for an off-axis light beam incident on the lens L_B , it is possible to suppress an occurrence of the chromatic coma.

By satisfying conditional expressions (20) and (21), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Moreover, by satisfying conditional expression (21), and conditional expressions (23-1) and (24-1) which will be described later, it is possible to correct the chromatic coma favorably while securing appropriately the thickness of the optical components forming the optical system, and besides, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (21), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Here, it is preferable that the following conditional expression (21') is satisfied instead of conditional expression (21).

$$0.01 < D_{max}/\phi_s < 2.85$$
 (21')

Moreover, it is more preferable that the following conditional expression (21") is satisfied instead of conditional expression (21).

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Furthermore, it is even more preferable that the following conditional expression (21") is satisfied instead of conditional expression (21).

$$0.03 < D_{max}/\phi_s < 2.0$$
 (21")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (22) is satisfied:

$$0.01 \le D_{G1max}/\phi_s \le 2.0$$
 (22)

where

 ${\rm D}_{G1max}$ denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens unit, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (22), it is possible to correct a chromatic coma more favorably.

By making so as not to fall below a lower limit value of conditional expression (22), it is possible to reduce deterioration of aberration due to a manufacturing error. For instance, decentering of a lens at the time of lens assembling is an example of the manufacturing error.

By making so as not to exceed an upper limit value of conditional expression (22), even in a case in which, the numerical aperture on the object side is large, it is possible to suppress the height of the off-axis marginal ray with respect to the height of the axial marginal ray from changing substantially between the lenses. For instance, let two adjacent lenses be a lens L_A and a lens L_B . The height of the off-axis marginal ray for the lens L_A and the height of the off-axis marginal ray for the lens L_B differ. However, by making a distance between the lens L_A and the lens L_B appropriate, it is possible to reduce the difference between the height of the off-axis marginal ray for the lens L₄ and the height of the off-axis marginal ray for the lens L_B . As a result, since it is possible to reduce a difference between the chromatic aberration for an off-axis light beam incident on the lens L_A and the chromatic aberration for an off-axis light beam incident on the lens L_B , it is possible to suppress an occurrence of the chromatic coma.

By satisfying conditional expressions (20) and (22), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Moreover, by satisfying conditional expression (22), and conditional expressions (23-1) and (24-1) which will be described later, it is possible to correct the chromatic coma favorably while securing appropriately the thickness of the optical components forming the optical system, and besides, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (22), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Here, it is preferable that the following conditional expression (22') is satisfied instead of conditional expression (22).

$$0.01 \le D_{G1max}/\phi_s \le 1.80$$
 (22')

Moreover, it is more preferable that the following conditional expression (22") is satisfied instead of conditional expression (22).

$$0.02 \le D_{G1max}/\phi_s \le 1.62$$
 (22")

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Furthermore, it is even more preferable that the following conditional expression (22") is satisfied instead of conditional expression (22).

$$0.03 \le D_{G1max}/\phi_s \le 1.46$$
 (22)

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi} \tag{23}$$

where,

 L_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the image-side 15 surface of the second image-side lens, and

 D_{oi} denotes a distance on the optical axis from the object up to the image.

By making so as not to fall below a lower limit value of conditional expression (23), even in an optical system having the overall length shortened, since it becomes possible to change the height of the principal ray emerged from a periphery of the object and reaching a periphery of the image comparatively gradually, it is possible to prevent a radius of curvature (paraxial radius of curvature) of a lens in the optical system from becoming excessively small. As a result, it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification.

Moreover, by satisfying conditional expressions (20) and (23), even in an optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably.

By satisfying conditional expression (23), and conditional expression (25) that will be described later, even in an optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably.

It is preferable that the following conditional expression (23') is satisfied instead of conditional expression (23).

$$0.42 < L_L/D_{oi} < 0.99$$
 (23')

Moreover, it is more preferable that the following conditional expression (23") is satisfied instead of conditional expression (23).

$$0.44 < L_L/D_{oi} < 0.98$$
 (23")

Furthermore, it is even more preferable that the following conditional expression (23") is satisfied instead of conditional expression (23).

$$0.47 < L_I/D_{oi} < 0.97$$
 (23"')

In the optical system according to the ninth embodiment, it is preferable that the following conditional expression (23-1) is satisfied:

$$0.6 \le L_I/D_{oi} \tag{23-1}$$

 L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side surface of the second image-side lens, and

 D_{oi} denotes a distance on the optical axis from the object to an image.

A technical significance of conditional expression (23-1) is same as the technical significance of conditional expression (23)

By satisfying conditional expression (23-1), and conditional expression (24-1) that will be described later, it is possible to achieve both, the favorable correction of the chromatic aberration (longitudinal chromatic aberration and chromatic aberration of magnification) in particular, and shortensing of the overall length of the optical system.

Here, it is preferable that the following conditional expression (23-1') is satisfied instead of conditional expression (23-1).

$$0.63 < L_I/D_{ei} < 0.99$$
 (23-1')

Moreover, it is more preferable that the following conditional expression (23-1") is satisfied instead of conditional expression (23-1).

$$0.66 < L_L/D_{oi} < 0.98$$
 (23-1")

Furthermore, it is even more preferable that the following conditional expression (23-1") is satisfied instead of conditional expression (23-1).

$$0.70 < L_L/D_{oi} < 0.97$$
 (23-1"')

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (24) is satisfied:

$$0.01 < 1/\nu d_{min} - 1/\nu d_{max}$$
 (24)

where.

 vd_{min} denotes a smallest Abbe's number from among $_{30}$ Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the optical system.

By making so as not to fall below a lower limit value of conditional expression (24), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification favorably. In a case in which, the optical system includes a diffractive optical element, a lens which forms the diffractive optical element is to be excluded from the 'lenses forming the optical system' in conditional expression (24).

By satisfying conditional expressions (20) and (24), even in an optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration 45 and the chromatic aberration of magnification more favorably.

By satisfying conditional expression (24), and conditional expression (25) that will be described later, even in the optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably.

Here, it is preferable that the following conditional expression (24') is satisfied instead of conditional expression (24). 55

$$0.012 < 1/v d_{min} - 1/v d_{max} < 0.050$$
 (24')

Moreover, it is more preferable that the following conditional expression (24") is satisfied instead of conditional expression (24).

$$0.014 < 1/v d_{min} - 1/v d_{max} < 0.040$$
 (24")

Furthermore, it is even more preferable that the following conditional expression (24") is satisfied instead of conditional expression (24).

$$0.016 < 1/v d_{min} - 1/v d_{max} < 0.035$$
 (24")

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In the optical system according to the ninth embodiment, it is preferable that the following conditional expression (24-1) is satisfied:

$$0.015 \!\!<\! 1/\!\nu d_{min} \!\!-\! 1/\!\nu d_{max} \tag{24-1}$$

where,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and vd_{max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the optical system.

A technical significance of conditional expression (24-1) is same as the technical significance of conditional expression (24).

By satisfying conditional expressions (15-1), (16), and (24-1), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification favorably. As a result, it is possible to observe a microscopic structure of a sample with a high resolution, even in color.

Here, it is preferable that the following conditional expression (24-1') is satisfied instead of conditional expression (24-1).

$$0.017 < 1/v d_{min} - 1/v d_{max} < 0.050$$
 (24-1')

Moreover, it is more preferable that the following conditional expression (24-1") is satisfied instead of conditional expression (24-1).

$$0.019 < 1/v d_{min} - 1/v d_{max} < 0.040$$
 (24-1")

Furthermore, it is even more preferable that the following conditional expression (24-1") is satisfied instead of conditional expression (24-1).

$$0.021 < 1/v d_{min} - 1/v d_{max} < 0.035$$
 (24-1"")

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where

 D_{os} denotes a distance on the optical axis from the object up to the stop, and

 \mathbf{D}_{oi} denotes a distance on the optical axis from the object up to the image.

By making so as not to fall below a lower limit value of conditional expression (25), it is possible to maintain appropriately the positive refractive power of the first lens unit while securing an appropriate thickness in lenses forming the first lens unit. As a result, it is possible to correct the chromatic aberration favorably while correcting a monochromatic aberration such as the curvature of field in the first lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the first lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the second lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

By making so as not to exceed an upper limit value of conditional expression (25), since it becomes possible to change the height of the principal ray emerged from the stop and reaching a periphery of the image comparatively gradually, it is possible to prevent a radius of curvature of a lens in the second lens unit from becoming excessively small. Therefore, it is possible to correct also the chromatic aberration favorably while correcting the monochromatic aberration such as the curvature of field in the second lens unit.

By satisfying conditional expressions (16), (19), (20), and (25), it is possible to correct the chromatic aberration more favorably while suppressing an occurrence of the monochromatic aberration such as the curvature of field, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (25), it is possible to realize simultaneously, enlargement of the numerical aperture on the object side, shortening of the overall length of the optical system, and favorable correction of the chromatic aberration, while suppressing the occurrence of the monochromatic aberration such as the curvature of field.

Here, it is preferable to that following conditional expression (25') is satisfied instead of conditional expression (25). 15

$$0.19 < D_{os}/D_{oi} < 0.76$$
 (25)

Moreover, it is more preferable that the following conditional expression (25") is satisfied instead of conditional expression (25).

$$0.21 < D_{os}/D_{oi} < 0.72$$
 (25")

Furthermore, it is even more preferable that the following conditional expression (25") is satisfied instead of conditional expression (25).

$$0.35 < D_{os}/D_{oi} < 0.69$$
 (25")

In the optical system according to the ninth embodiment, it is preferable that the following conditional expression (25-1) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.65$$
 (25-1)

where.

 D_{os} denotes a distance on an optical axis from the object up $_{35}$ to the stop, and

 D_{ot} denotes a distance on the optical axis from the object up to an image.

A technical significance of conditional expression (25-1) is same as the technical significance of conditional expression $_{40}$ (25).

By satisfying conditional expressions (23-1), (24-1), and (25-1), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (25-1') is satisfied instead of conditional expression (25-1).

$$0.17 < D_{os}/D_{oi} < 0.62$$
 (25-1')

Moreover, it is more preferable that the following conditional expression (25-1") is satisfied instead of conditional expression (25-1).

$$0.21 < D_{os}/D_{oi} < 0.59$$
 (25-1")

Furthermore, it is even more preferable that the following conditional expression (25-1") is satisfied instead of conditional expression (25-1).

$$0.35 < D_{os}/D_{oi} < 0.56$$
 (25-1"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (26) is satisfied:

$$0.95 < /\phi_{G1o}/(2 \times Y/|\beta|) \tag{26}$$

where.

 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical system, and

 β denotes an imaging magnification of the optical system. By making so as not to fall below a lower limit value of conditional expression (26), it is possible to make small a difference in angles of incidence when the off-axis marginal ray is incident on the lens, or in other words, to make small a difference in an angle of incidence of an upper-side light ray and an angle of incidence of a lower-side light ray. Accordingly, it is possible to correct the coma and the chromatic coma favorably. Moreover, in an optical system having the numerical aperture on the object side enlarged, it is possible to correct the coma and the chromatic coma favorably.

Here, it is preferable that the following conditional expression (26') is satisfied instead of conditional expression (26).

$$1.00 < \phi_{GL}/(2 \times Y/|\beta|) < 10.00 \tag{26}$$

Moreover, it is more preferable that the following conditional expression (26") is satisfied instead of conditional expression (26).

$$1.05 < \phi_{G1o}/(2 \times Y/|\beta|) < 7.00$$
 (26")

Furthermore, it is even more preferable that the following conditional expression (26") is satisfied instead of conditional expression (26).

$$1.11 \le \phi_{G1o}/(2 \times Y/|\beta|) \le 5.00$$
 (26"')

In the optical system according to the present embodiment, it is preferable that the following conditional expression (27) is satisfied:

$$0 < BF/L_I < 0.4$$
 (27)

where

BF denotes a distance on an optical axis from the imageside surface of the second image-side lens up to the image, and

 ${\rm L}_L$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

By making so as not to fall below a lower limit value of conditional expression (27), it is possible to increase a distance between the second image-side lens and the image pickup element. Accordingly, even when a ghost is generated due to multiple reflection between the second image-side lens and the image pickup element, it is possible to prevent the ghost from being incident on a surface of the image pickup element with a high density.

By making so as not to exceed an upper limit value of conditional expression (27), it is possible to prevent occupancy of a space of the back focus with respect to the overall length of the optical system from becoming excessively large. Accordingly, since there is an increase in a degree of freedom of positions at the time of disposing the lenses, it is possible to correct various aberrations favorably. For instance, by disposing a lens having a function of correcting chromatic aberration in the first lens unit and the second lens unit, and adjusting a positional relationship of these lenses, it is possible to achieve both, the favorable correction of the longitudinal chromatic aberration and the favorable correction of the chromatic aberration of magnification.

By satisfying conditional expressions (16), (19), (20), and (27), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (23-1), (24-1), and (27), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall 5 length of the optical system.

By satisfying conditional expressions (18) and (27), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (27') is satisfied instead of conditional expression (27).

$$0.01 < BF/L_L < 0.36$$
 (27')

Moreover, it is more preferable that the following conditional expression (27") is satisfied instead of conditional expression (27).

$$0.02 < BF/L_L < 0.32$$
 (27")

Furthermore, it is even more preferable that the following conditional expression (27") is satisfied instead of conditional expression (27).

$$0.03 < BF/L_L < 0.28$$
 (27"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where,

BF denotes a distance on an optical axis from the imageside surface of the second image-side lens up to the image, 35 and

Y denotes a maximum image height in an overall optical system.

By satisfying conditional expression (28), it is possible to correct an aberration more favorably, particularly an aberration in a peripheral portion of an image, while shortening the overall length of the optical system.

By making so as not to fall below a lower limit value of conditional expression (28), it is possible to increase a distance between the second image-side lens and the image pickup element. Accordingly, even when a ghost is generated due to multiple reflection between the second image-side lens and the image pickup element, it is possible to prevent the ghost from being incident on the surface of the image pickup element with a high density.

By making so as not to exceed an upper limit value of conditional expression (28), it is possible to prevent the occupancy of a space of the back focus with respect to the overall length of the optical system from becoming excessively large. Accordingly, since there is an increase in the degree of freedom of positions at the time of disposing the lenses, it is possible to correct various aberrations favorably. For instance, by disposing the lens having the function of correcting chromatic aberration in the first lens unit and the second lens unit, and adjusting a positional relationship of these lenses, it is possible to achieve both, the favorable correction of the longitudinal chromatic aberration and the favorable correction of the chromatic aberration of magnification.

Here, it is preferable that the following conditional expression (28') is satisfied instead of conditional expression (28). 65

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Moreover, it is more preferable that the following conditional expression (28") is satisfied instead of conditional expression (28).

$$0.10 < BF/Y < 5.67$$
 (28")

Furthermore, it is even more preferable that the following conditional expression (28") is satisfied instead of conditional expression (28).

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (29) is satisfied:

$$-0.2 < \phi_{G1o}/R_{G1o} < 3.0$$
 (29)

where,

 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens, and

 R_{G1o} denotes a radius of curvature of the object-side surface of the first object-side lens.

In an optical system in which, the numerical aperture on the object side has been enlarged and the working distance made long, a diameter of a light beam incident on the first object-side lens is spread sufficiently. By making so as not to fall below a lower limit value of conditional expression (29), even in such optical system, it is possible to suppress the light beam that is incident, from being diverged. As a result, in a lens disposed on the image side of the first object-side lens, it is possible to suppress an occurrence of various aberrations such as the spherical aberration and the coma aberration.

By making so as not to exceed an upper limit value of conditional expression (29), since it is possible to prevent difference in angles of incidence when the off-axis marginal ray is incident on the lens, or in other words, to prevent the difference in an angle of incidence of an upper-side light ray and an angle of incidence of a lower-side light ray from becoming excessively large, it is possible to suppress the occurrence of the coma.

Particularly, in a case in which, the working distance has been secured sufficiently, in the optical system with the large numerical aperture on the object side, it is possible to correct various aberrations such as the coma more favorably while shortening the overall length of the optical system.

Here, it is preferable that the following conditional expression (29') is satisfied instead of conditional expression (29).

$$-0.15 < \phi_{G1} / R_{G1} < 2.10$$
 (29°)

Moreover, it is more preferable that the following conditional expression (29") is satisfied instead of conditional expression (29).

$$-0.10 < \phi_{G1} / R_{G1} < 1.47$$
 (29")

Furthermore, it is even more preferable that the following conditional expression (29") is satisfied instead of conditional expression (29).

$$-0.05 < \phi_{G1o} / R_{G1o} < 1.03$$
 (29")

In the optical system according to the present embodiment, it is preferable that the second lens unit includes four lenses, and at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and an object-side surface of the positive lens from among the positive lenses, which is positioned nearest to the object side, is a convex surface that is convex toward the object side.

By making such an arrangement, it is possible to correct various aberrations, particularly the chromatic aberration of

0.05<*BF/Y*<6.30

magnification more favorably, while shortening the overall length of the optical system. In other words, it is possible to make an adjustment to position the principal point of the second lens unit on the object side, and to dispose a plurality of lenses having different optical characteristics. Therefore, it is possible to correct the chromatic aberration and other various aberrations in the second lens unit favorably while shortening a conjugate length (a distance from the object up to the image). As a result, it is possible to correct favorably various aberrations including the chromatic aberration of magnification in the overall optical system while shortening the overall length of the optical system.

In the optical system according to the present embodiment, it is preferable that the first lens unit includes a first image-side lens which is disposed nearest to the image side, and a distance of two lenses positioned on two sides of the stop is fixed, and the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

where

 ${\rm D}_{G1G2}$ denotes a distance on the optical axis from the image-side surface of the first image-side lens up to the object-side surface of the second object-side lens, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (30), it is possible to maintain appropriately a balance between a predetermined refraction effect in the first lens unit and a predetermined refraction effect in the second lens unit, while shortening the overall length of the optical system. As a result, it is possible to correct the chromatic aberration of magnification and other off-axis aberrations more favorably. The predetermined refraction effect is same as the predetermined refraction effect described in conditional expression (20).

By making so as not to exceed an upper limit value of conditional expression (30), it is possible to make the optical system thin while preventing an angle of incidence of an off-axis light beam incident on the second lens unit from becoming excessively small. Therefore, it is possible to suppress the predetermined refraction effect in the first lens unit from becoming excessively large, and moreover not to let the predetermined refraction effect in the second lens unit become excessively small, while maintaining the required imaging magnification. Accordingly, since it is possible to maintain appropriately the balance between the predetermined refraction effect in the first lens unit and the predetermined refraction effect in the second lens unit, it is possible to correct the chromatic aberration of magnification and other off-axis aberrations more favorably.

Here, it is preferable that the following conditional expression (30') is satisfied instead of conditional expression (30).

$$0.01 < D_{G1G2}/\phi_s < 1.80$$
 (30')

Moreover, it is more preferable that the following conditional expression (30") is satisfied instead of conditional expression (30).

$$0.03 < D_{G1G2} / \phi_s < 1.53$$
 (30")

Furthermore, it is even more preferable that the following conditional expression (30") is satisfied instead of conditional expression (30).

$$0.05 < D_{G1G2} / \phi_s < 1.30$$
 (30"")

In the optical system according to the eighth embodiment and the optical system according to the ninth embodiment, it 46

is preferable that the following conditional expression (31) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.5$$
 (31)

where

 L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 ${\rm L}_{G2}$ denotes a distance on the optical axis from an object-side surface of the second object-side lens up to the image side surface of the second image-side lens.

By making so as not to fall below a lower limit value of conditional expression (31), it is possible to maintain appropriately the positive refractive power of the first lens unit while securing the appropriate thickness of lenses forming the first lens unit. Therefore, it is possible to position the principal point on the object side and to shorten the overall length of the optical system while correcting the longitudinal chromatic aberration favorably.

By making so as not to exceed an upper limit value of conditional expression (31), in a case of securing the appropriate working distance, since it is possible to change the height of a principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually, it is possible to prevent a radius of curvature of a lens in the second lens unit from becoming excessively small. Therefore, it is possible to correct the chromatic aberration of magnification more favorably.

By satisfying conditional expressions (16), (19), (20), and (31), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing sufficient working distance, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (23-1), (24-1), and (31), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (31') is satisfied instead of conditional expression (31).

$$0.14 < L_{G1}/L_{G2} < 1.43$$
 (31)

Moreover, it is more preferable that the following conditional expression (31") is satisfied instead of conditional expression (31).

$$0.20 < L_{GI}/L_{G2} < 1.35$$
 (31")

Furthermore, it is even more favorable that the following conditional expression (31") is satisfied instead of conditional expression (31).

$$0.29 < L_{G1}/L_{G2} < 1.29$$
 (31"")

In the optical system according to the tenth embodiment, it is preferable that the following conditional expression (31-1) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.4$$
 (31-1)

where,

 L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 ${\cal L}_{G2}$ denotes a distance on the optical axis from an object-side surface of the second object-side lens up to the image side surface of the second image-side lens.

A technical significance of conditional expression (31-1) is same as the technical significance of conditional expression (31).

By satisfying conditional expressions (18) and (31-1), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing the appropriate working distance, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (31-1') is satisfied instead of conditional expression (31-1).

$$0.14 < L_{G1}/L_{G2} < 1.33$$
 (31-1')

Moreover, it is more preferable that the following conditional expression (31-1") is satisfied instead of conditional expression (31-1).

$$0.20 < L_{GI}/L_{G2} < 1.26$$
 (31-1")

Furthermore, it is even more preferable that the following conditional expression (31-1") is satisfied instead of conditional expression (31-1).

$$0.29 < L_{G1}/L_{G2} < 1.20$$
 (31-1"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (32) is satisfied:

$$0.1 < L_{G1s} / L_{sG2} < 1.5$$
 (32)

where.

 L_{G1s} denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the stop, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens.

By satisfying conditional expression (32), it is possible to correct more favorably an aberration in a peripheral portion of the image, particularly the chromatic aberration of magnification while shortening the overall length of the optical system.

By making so as not to fall below a lower limit value of conditional expression (32), it is possible to secure sufficiently a space for disposing the first lens unit. Accordingly, it 40 is possible to secure an appropriate thickness in lenses forming the first lens unit, and to increase a degree of freedom of selection of curvature of a lens surface, and to dispose a large number of lenses having different optical characteristics. Therefore, it is possible to correct also the chromatic aberra- 45 tion favorably while correcting the monochromatic aberration in the first lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the first lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the second lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

By making so as not to exceed an upper limit value of 55 conditional expression (32), it is possible to secure sufficiently a space for disposing the second lens unit. Accordingly, it is possible to secure an appropriate thickness in lenses forming the second lens unit, and to increase a degree of freedom of selection of curvature of a lens surface, and to 60 dispose a large number of lenses having different optical characteristics. Therefore, it is possible to correct also the chromatic aberration favorably while correcting the monochromatic aberration in the second lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in 65 the second lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the first lens unit

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becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the first lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

Here, it is preferable that the following conditional expression (32') is satisfied instead of conditional expression (32).

$$0.14 < L_{G1s}/L_{sG2} < 1.35$$
 (32')

Moreover, it is more preferable that the following conditional expression (32") is satisfied instead of conditional expression (32).

$$0.20 < L_{G1s} / L_{sG2} < 1.22$$
 (32")

Furthermore, it is even more preferable that the following conditional expression (32") is satisfied instead of conditional expression (32).

$$0.29 < L_{G1} / L_{sG2} < 1.09$$
 (32"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (33) is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0 \tag{33}$$

where.

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 $\phi_{G1,max}$ denotes a maximum effective diameter from among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among effective diameter of lenses in the second lens unit.

By satisfying conditional expression (33), it is possible to maintain appropriately the balance between a predetermined refraction effect in the first lens unit and a predetermined refraction effect in the second lens unit while shortening the overall length of the optical system. As a result, it is possible to correct the chromatic aberration of magnification and other off-axis aberrations more favorably.

By making so as not to fall below a low limit value of conditional expression (33), it is possible to make the optical system thin while preventing a diameter of a lens forming the first lens unit from becoming excessively small. Therefore, in a region on the object side of the first lens unit, it is possible to prevent a light ray height of an off-axis light beam from becoming excessively low. Accordingly, since it is possible to secure appropriately a space in an optical axial direction of the first lens unit, it is possible to correct the chromatic aberration of magnification favorably.

By making so as not to exceed an upper limit value of conditional expression (33), it is possible to make the optical system thin while preventing a diameter of a lens forming the second lens unit from becoming excessively small. In this case, since it is not necessary any more to make an angle of incidence of an off-axis light beam that is incident on the second lens unit excessively small, it is possible to suppress the predetermined refraction effect in the first lens unit from becoming excessively large, and moreover not to let the predetermined refraction effect in the second lens unit become excessively small while maintaining the required imaging magnification. In such manner, since it is possible to maintain appropriately the balance between the predetermined refraction effect in the first lens unit and the predetermined refraction effect in the second lens unit, it is possible to correct the chromatic aberration of magnification and other off-axis aberrations more favorably.

Here, it is preferable that the following conditional expression (33') is satisfied instead of conditional expression (33).

$$0.84 \le \phi_{G1max}/\phi_{G2max} < 4.50$$
 (33')

Moreover, it is more preferable that the following conditional expression (33") is satisfied instead of conditional expression (33).

$$0.88 \le \phi_{G1max}/\phi_{G2max} < 3.50$$
 (33")

Furthermore, it is even more preferable that the following conditional expression (33") is satisfied instead of conditional expression (33).

$$0.93 \le \phi_{G1max}/\phi_{G2max} < 2.50$$
 (33"") 10

In the optical system according to the present embodiment, it is preferable that the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where

 D_{os} denotes a distance on an optical axis from the object up to the stop, and

 ${\cal L}_{G1}$ denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the first image-side lens.

By making so as not to fall below a lower limit value of conditional expression (34), it is possible to secure sufficiently a space for disposing the second lens unit. Accord- 25 ingly, it is possible to secure an appropriate thickness in lenses forming the second lens unit, and to increase a degree of freedom of selection of curvature of a lens surface, and to dispose a large number of lenses having different optical characteristics. Therefore, it is possible to correct also the 30 chromatic aberration favorably while correcting the monochromatic aberration in the second lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the second lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the first lens unit 35 becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the first lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

By making so as not to exceed an upper limit value of 40 conditional expression (34), it is possible to secure sufficiently a space for disposing the first lens unit. Accordingly, it is possible to secure an appropriate thickness in lenses forming the first lens unit, and to increase a degree of freedom of selection of curvature of a lens surface, and to dispose a large 45 number of lenses having different optical characteristics. Therefore, it is possible to correct also the chromatic aberration favorably while correcting the monochromatic aberration in the first lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the first lens unit 50 favorably, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the second lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in 55 the overall optical system favorably.

By satisfying conditional expressions (16), (19), (20), and (34), it is possible to correct the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of 60 the overall length of the optical system.

By satisfying conditional expressions (23-1), (24-1), and (34), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

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By satisfying conditional expressions (18) and (34), it is possible to correct the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (34') is satisfied instead of conditional expression (34).

$$0.7 < D_{os} / L_{GI} < 3.8$$
 (34')

Moreover, it is more preferable that the following conditional expression (34") is satisfied instead of conditional expression (34).

$$1.0 < D_{os}/L_{GI} < 3.6$$
 (34")

Furthermore, it is even more preferable that the following conditional expression (34") is satisfied instead of conditional expression (34).

$$1.5 < D_{os}/L_{G1} < 3.4$$
 (34"')

In the optical system according to the present embodiment, it is preferable that the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{ob}/CRA_{ing} \le 0.5$$
 (36)

where

 ${\rm D}_{ENP}$ denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical system,

 ${\rm CRA}_{obj}$ denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

CRA_{img} denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle.

By making so as not to fall below a lower limit value of conditional expression (36), since an angle of incidence of an off-axis light beam on an image pickup surface does not become excessively large, it is possible to prevent degradation of an amount of light at periphery more efficiently.

By making so as not to exceed an upper limit value of conditional expression (36), a divergence effect is imparted to a region near an image side of the optical system, and it is possible to make an arrangement of the optical system to be of a telephoto type. As a result, it is possible to shorten the overall length of the optical system.

Satisfying conditional expressions (16), (19), (20), (35), and (36) is advantageous for favorable correction of the chromatic aberration and for shortening the overall length of the optical system while securing the amount of light at periphery.

Satisfying conditional expressions (23-1), (24-1), (35), and (36) is advantageous for favorable correction of the chromatic aberration, and for shortening the overall length of the optical system while securing the amount of light at periphery.

Satisfying conditional expressions (18), (35), and (36) is advantageous for favorable correction of the chromatic aberration, and for shortening the overall length of the optical system while securing the amount of light at periphery.

Here, it is preferable that the following conditional expression (36') is satisfied instead of conditional expression (36).

$$0.01 \le CRA_{obj}/CRA_{img} \le 0.48$$
 (36')

Moreover, it is more preferable that the following conditional expression (36") is satisfied instead of conditional expression (36).

$$0.02 \le CRA_{obj}/CRA_{img} \le 0.46$$
 (36")

Furthermore, it is even more preferable that the following 10 conditional expression (36") is satisfied instead of conditional expression (36).

$$0.03 \le CRA_{obi}/CRA_{img} < 0.44$$
 (36"")

In the optical system according to the present embodiment, it is preferable that the first lens unit includes the first object-side lens, and a lens which disposed to be adjacent to the first object-side lens, and at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.

By one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens, on the image side of the first object-side lens, having a positive refractive power, it is possible to position the principal point of the first lens unit on the object side. As a result, it is possible to secure the working distance sufficiently. The first object-side lens and the lens disposed to be adjacent to the first object-side lens, on the image side of the first object-side lens may be in separated state or may be in cemented state.

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the first object-side lens has a positive refractive power. Moreover, it is preferable that the following conditional expression (37) is satisfied:

$$0.05 < f_{G1} / f$$
 (37) 35

where.

 ${\rm f}_{G1o}$ denotes a focal length of the first object-side lens, and f denotes a focal length of an overall optical system.

In the optical system which satisfies conditional expression (20), by imparting the positive refractive power to the first object-side lens, a height of the off-axis marginal ray can be suppressed while positioning the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (37), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

In the optical system which satisfies conditional expression (25), by imparting the positive refractive power to the first object-side lens, the height of the off-axis marginal ray can be suppressed while positioning the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (37), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

Here, it is preferable that the following conditional expression (37') is satisfied instead of conditional expression (37).

$$0.06 < f_{G1} / f < 50.00$$
 (37')

Moreover, it is more preferable that the following conditional expression (37") is satisfied instead of conditional expression (37).

$$0.07 < f_{G1} / f < 25.00$$
 (37")

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Furthermore, it is even more preferable that the following conditional expression (37") is satisfied instead of conditional expression (37).

$$0.10 < f_{G1} / f < 20.00$$
 (37")

In the optical system according to the ninth embodiment, it is preferable that the first object-side lens has a negative refractive power. Moreover, it is preferable that the following conditional expression (37-1) is satisfied:

$$f_{G1}/f < -0.01$$
 (37-1)

where,

 \mathbf{f}_{Glo} denotes a focal length of the first object-side lens, and f denotes a focal length of an overall optical system.

In the optical system which satisfies conditional expressions (23-1) and (24-1), by imparting the negative refractive power to the first object-side lens, it is possible to secure sufficiently a space for disposing the first lens unit, as well as to maintain appropriately a height of the off-axis marginal ray in a region on the object side of the first lens unit. Furthermore, by satisfying conditional expression (37-1), it is possible to suppress the off-axis marginal ray from being diverged excessively. Accordingly, it is possible to correct aberrations such as the chromatic aberration of magnification favorably.

Here, it is preferable that the following conditional expression (37-1') is satisfied instead of conditional expression (37-1).

$$-500.00 < f_{G1} / f < -0.02$$
 (37-1')

Moreover, it is more preferable that the following conditional expression (37-1") is satisfied instead of conditional expression (37-1).

$$-250.00 < f_{G1} / f < -0.04$$
 (37-1")

Furthermore, it is even more preferable that the following conditional expression (37-1") is satisfied instead of conditional expression (37-1).

$$-100.00 < f_{G1} / f < -0.08$$
 (37-1""

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the object-side surface of the first object-side lens is convex toward the object side. Moreover, it is preferable that the following conditional expression (38) is satisfied:

$$0.02 < R_{G1} / WD$$
 (38)

where,

 $R_{{\cal G}{\rm I}o}$ denotes a radius of curvature of the object-side sur- $_{50}$ face of the first object-side lens, and

WD denotes a distance on an optical axis from the object up to an object-side side surface of the first object-side lens.

In the optical system which satisfies the conditional expression (20), by imparting the positive refractive power to the object-side surface of the first object-side lens, a height of the off-axis marginal ray can be suppressed while positioning the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (38), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

In the optical system which satisfies the conditional expression (25), by imparting the positive refractive power to the object-side surface of the first object-side lens, the height of the off-axis marginal ray can be suppressed while position-

ing the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (38), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

Here, it is preferable that the following conditional expression (38') is satisfied instead of conditional expression (38).

$$0.02 < R_{G1} / WD < 20.00$$
 (38°)

Moreover, it is more preferable that the following conditional expression (38") is satisfied instead of conditional expression (38).

$$0.03 < R_{G1} / WD < 15.00$$
 (38")

Furthermore, it is even more preferable that the following conditional expression (38") is satisfied instead of conditional expression (38).

$$0.04 < R_{G1} / WD < 10.00$$
 (38')

In the optical system according to the ninth embodiment, it is preferable that the object-side surface of the first object-side lens is concave toward the object side. Moreover, it is preferable that the following conditional expression (38-1) is 25 satisfied:

$$R_{G1o}/WD < -0.1$$
 (38-1)

where.

 R_{G1o} denotes the radius of curvature of the object-side 30 surface of the first object-side lens, and

WD denotes a distance on an optical axis from the object up to an object-side side surface of the first object-side lens.

In the optical system which satisfies conditional expressions (23-1) and (24-1), by imparting the negative refractive 35 power to the object-side surface of the first object-side lens, it is possible to secure sufficiently a space for disposing the first lens unit, as well as to maintain appropriately the height of the off-axis marginal ray in a region on the object side of the first lens unit. Furthermore, by satisfying conditional expression 40 (38-1), it is possible to suppress divergence of the off-axis marginal ray. Accordingly, it is possible to correct aberrations such as the chromatic aberration of magnification favorably.

Here, it is preferable that the following conditional expression (38-1') is satisfied instead of conditional expression (38-45 1).

$$-250.00 < R_{G1} / WD < -0.14$$
 (38-1')

Moreover, it is more preferable that the following conditional expression (38-1") is satisfied instead of conditional 50 expression (38-1).

$$-100.00 < R_{G1} / WD < -0.20$$
 (38-1")

Furthermore, it is even more preferable that the following conditional expression (38-1") is satisfied instead of conditional expression (38-1).

$$-50.00 < R_{G1o} / WD < -0.29$$
 (38-1"")

In the optical system according to the present embodiment, it is preferable that the second lens unit includes a predetermined lens unit nearest to the image, and the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and the two single lenses consist in order from the object side, a lens having a negative refractive power, 65 and a lens having one of a positive refractive power and a negative refractive power.

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In the optical system which satisfies conditional expression (20), by further disposing the predetermined lens unit, or in other words, a lens unit having a negative refractive power, at a position nearest to the image side of the second lens unit, it is possible to position the principal point on the object side. Accordingly, since it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually while shortening the overall length of the optical system, it is possible to correct favorably the chromatic aberration of magnification in particular.

In the optical system which satisfies conditional expressions (21), (23-1), and (24-1), by further disposing the predetermined lens unit, or in other words, a lens unit having a negative refractive power, at a position nearest to the image side of the second lens unit, it is possible to position the principal point on the object side. Accordingly, since it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually while shortening the overall length of the optical system, it is possible to correct favorably the chromatic aberration of magnification in particular.

In the optical system which satisfies conditional expressions (18) and (25), by further disposing the predetermined lens unit, or in other words, a lens unit having a negative refractive power, at a position nearest to the image side of the second lens unit, it is possible to position the principal point on the object side. Accordingly, since it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually while shortening the overall length of the optical system, it is possible to correct favorably the chromatic aberration of magnification in particular.

In the optical system according to the present embodiment, it is preferable that an image-side surface of the second image-side lens is concave toward the image side, and that the following conditional expression (39) is satisfied:

$$0.1 \le R_{G2i}/BF \tag{39}$$

where.

 R_{G2i} denotes a radius of curvature of the image-side surface of the second image-side lens, and

BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the image.

Since it is possible to position the principal point of the second lens unit on the object side, it is possible to shorten the optical system while maintaining a favorable imaging performance.

Here, it is preferable that the following conditional expression (39') is satisfied instead of conditional expression (39).

$$0.2 < R_{G2} \neq BF \tag{39}$$

Moreover, it is more preferable that the following conditional expression (39") is satisfied instead of conditional expression (39).

$$0.4 < R_{G2} / BF$$
 (39")

Furthermore, it is even more preferable that the following conditional expression (39") is satisfied instead of conditional expression (39).

$$0.8 < R_{G2} / BF$$
 (39")

In the optical system according to the present embodiment, it is preferable that the second lens unit includes a predetermined lens unit nearest to the image, and the positive lens is

disposed on the object side of the predetermined lens unit, and the positive lens is disposed to be adjacent to the predetermined lens unit.

By disposing the positive lens on the object side of the predetermined lens unit, and disposing the positive lens to be 5 adjacent to the predetermined lens unit, it is possible to suppress an angle of incidence of an off-axis light beam on the second lens unit from becoming large, while shortening the overall length of the optical system. As a result, since it is possible to prevent a height of a light ray of the off-axis light beam from becoming excessively high, it is possible to make the optical system thin. Moreover, although a distortion in a positive direction occurs due to a divergence effect in the predetermined lens unit, it is possible to correct the distortion favorably by the positive lens. The predetermined lens and the 15 positive lens may be disposed separately, or may be

In the optical system according to the present embodiment, it is preferable that an image-side surface of the first imageside lens is concave toward the image side, and the following 20 conditional expression (40) is satisfied:

$$0.2 < R_{G1i}/D_{G1is}$$
 (40)

where.

 R_{GI} denotes a radius of curvature of the image-side surface 25 of the first image-side lens, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop.

By making the image-side surface of the first image-side lens concave toward the image side, it is possible to position 30 the principal point of the first lens unit on the object side. Accordingly, it is possible to secure an appropriate working distance. Moreover since a lens surface which is a concave surface is directed toward the stop, it is possible to suppress image (position at which, the image height is high).

Furthermore, by satisfying conditional expression (40), since it is possible to maintain appropriately the divergence effect in a peripheral portion of the optical system, it is possible to suppress the occurrence of the chromatic coma.

Here, it is preferable that the following conditional expression (40') is satisfied instead of conditional expression (40).

$$0.4 < R_{G1i}/D_{G1is} \tag{40}$$

Moreover, it is more preferable that the following condi- 45 tional expression (40") is satisfied instead of conditional expression (40).

$$0.8 < R_{G1i'}/D_{G1is}$$
 (40")

Furthermore, it is even more preferable that the following 50 conditional expression (40") is satisfied instead of conditional expression (40).

$$1.6 < R_{G1} / D_{G1is}$$
 (40"")

In the optical system according to the present embodiment, 55 it is preferable that the first lens unit includes not less than three positive lenses, and at least two positive lenses from among the positive lenses are disposed to be adjacent, and an object-side surface in the two positive lenses disposed to be adjacent is a convex surface which is convex toward the object 60

By making such an arrangement, it is possible to distribute the positive refractive power in the first lens unit to three or more than three lenses, and to dispose each lens at a different position. As a result, it is possible to converge a light beam 65 incident with a high numerical aperture while suppressing an occurrence of aberration, and to correct the curvature of field

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and the chromatic aberration of magnification favorably. Furthermore, by disposing two of the three or more than three lenses to be adjacent, and letting the object-side surface to be a convex surface convex toward the object side, it is possible to correct the spherical aberration favorably.

In the optical system according to the present embodiment, it is preferable that from among the three or more than three positive lenses, at least one positive lens is an aspherical lens, and at least one surface of the aspherical lens is an aspherical

By making such an arrangement, it is possible to correct the off-axis aberration of higher order.

In the optical system according to the present embodiment, it is preferable that the first lens unit includes at least one cemented lens.

By cementing a lens having a function of correcting the chromatic aberration with another lens to form a cemented lens, and by disposing the cemented lens in the first lens unit, it is possible to suppress the occurrence of the chromatic aberration of magnification simultaneously while correcting the longitudinal chromatic aberration in the first lens unit. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification in the optical system favorably.

In the optical system according to the present embodiment, it is preferable that a positive lens is disposed on the object side of the cemented lens in the first lens unit, and the positive lens is a single lens.

By making such an arrangement, it is possible to distribute the positive refractive power in the first lens unit to the cemented lens and the positive lens. As a result, it is possible to correct the spherical aberration more favorably.

In the optical system according to the present embodiment, the occurrence of the coma in a peripheral portion of the 35 it is preferable that the second lens unit includes at least one cemented lens.

> By cementing a lens having a function of correcting the chromatic aberration with another lens to form a cemented lens, and by disposing the cemented lens in the second lens unit, it is possible to suppress the occurrence of the chromatic aberration of magnification simultaneously while correcting the longitudinal chromatic aberration in the second lens unit. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification in the optical system favorably.

> In the optical system according to the present embodiment, it is preferable that a positive lens is disposed on the image side of the cemented lens in the second lens unit, and the positive lens is a single lens.

> By making such an arrangement, it is possible to distribute the positive refractive power in the second lens unit to the cemented lens and the positive lens. As a result, it is possible to correct the spherical aberration more favorably.

> In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the first object-side lens has a positive refractive power, and the first object-side lens is either a single lens or a cemented lens.

> By imparting the positive refractive power to the first object-side lens, it is possible to position the principal point of the first lens unit on the object side as much as possible. As a result, it is possible to achieve both, securing an appropriate working distance and small-sizing of the optical system. In a case in which, further longer working distance is necessary, it is preferable to make such arrangement.

> It is preferable that the optical system according to the present embodiment includes at least one lens having an

inflection point, and in the lens having the inflection point, the number of inflection points in a shape of a lens surface is one or more than one.

By making such an arrangement, it is possible to correct the off-axis aberration of higher order favorably.

In the optical system according to the present embodiment, it is preferable that a shape of at least one lens surface of the second image-side lens is a shape having an inflection point.

By making such an arrangement, it is possible to correct the off-axis aberration of higher order favorably, and apart from this, it is possible to achieve both, the small-sizing of the optical system and reduction of an angle of incidence on the image pickup element. For small-sizing of the optical system, it is desirable to make an arrangement such that in the second lens unit, a refractive power in a region closer to the image side becomes a negative refractive power, and accordingly, to position the principal point of the second lens unit on the object side. Moreover, for reducing the angle of incidence on the image pickup element, at least one surface of the second image-side lens is let to have a shape having at least one 20 inflection point. By making such an arrangement, it is possible to make small an angle of incidence of an off-axis light beam on the image surface.

In the optical system according to the present embodiment, it is preferable that the first lens unit includes at least one 25 negative lens, and the negative lens is a single lens.

By making such an arrangement, it is possible to correct the chromatic aberration sufficiently in the first lens unit. As a result, it is possible to correct the chromatic aberration of magnification favorably while correcting the longitudinal 30 chromatic aberration in the overall optical system.

In the optical system according to the present embodiment, it is preferable that the first image-side lens is a cemented lens.

In the first lens unit, by disposing a negative lens near the stop, it is possible to correct favorably the longitudinal chro- 35 matic aberration and the curvature of field simultaneously. Here, by disposing a positive lens at a position adjacent to the negative lens, and cementing the negative lens and the positive lens, it is possible to suppress the occurrence of the chromatic aberration of magnification.

Moreover, in the optical system according to the present embodiment, it is preferable that the second object-side lens is a cemented lens.

In the second lens unit, by disposing a negative lens near the stop, it is possible to correct favorably the longitudinal 45 chromatic aberration and the curvature of field simultaneously. Here, by disposing a positive lens at a position adjacent to the negative lens, and cementing the negative lens and the positive lens, it is possible to suppress the occurrence of the chromatic aberration of magnification.

In the optical system according to the eighth embodiment, it is preferable that at the time of focusing, some of the lenses from among the plurality of lenses in the second lens unit move in an optical axial direction.

Since the second lens unit is positioned on the image side of 55 tional expression (41). the first lens unit, a light beam diameter in the second lens unit is smaller than a light beam diameter in the first lens unit. Therefore, even when a lens is moved in the second lens unit, a fluctuation in aberration is small. Therefore, when the movement of lenses at the time of focusing is carried out by using some of the lenses from among the plurality of lenses in the second lens unit, it is possible to make small the fluctuation in aberration due to the movement of the lenses. In the optical system according to the eighth embodiment, it is preferable that at the time of focusing, an optical system from the first-object side lens up to the second image-side lens moves integrally in the optical axial direction.

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In the optical system according to the present embodiment, it is preferable that at the time of focusing, an air space from the first object-side lens up to the second image-side lens does not change.

By making such an arrangement, at the time of focusing, a positional relationship of lenses (single lens or cemented lens) positioned on both sides of the stop does not change. As a result, since a balance of the chromatic aberration of magnification in the first lens unit and the chromatic aberration of magnification in the second lens unit is not disrupted, it is possible to maintain a favorable imaging performance even when the focusing is carried out. In the first lens unit and the second lens unit, it is desirable that a lens and a pair of lenses having a significant effect of correcting the chromatic aberration is disposed near the stop for correcting the chromatic aberration of magnification favorably.

In the optical system according to the eighth embodiment, it is preferable that the following conditional expression (37-2) is satisfied:

$$0.5 < f_{G1} / f < 100$$
 (37-2)

where.

 \mathbf{f}_{G1o} denotes a focal length of the first object-side lens, and f denotes a focal length of an overall optical system.

Moreover, in the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (41) is satisfied:

$$0.5 < f_{G1} / f_{G1} < 20$$
 (41)

where,

 \mathbf{f}_{G1o} denotes a focal length of the first object-side lens, and \mathbf{f}_{G1} denotes a focal length of the first lens unit.

By making so as not to fall below a lower limit value of conditional expression (41), it is possible to prevent the positive refractive power of the first object-side lens from becoming excessively small. Accordingly, it is possible to position the principal point of the first lens unit on the object side as much as possible. As a result, it is possible to achieve both, securing an appropriate working distance and small-sizing of the optical system. In a case in which, further longer working distance is necessary, it is preferable to make such arrange-

Here, it is preferable that the following conditional expression (41') is satisfied instead of conditional expression (41).

$$0.71 \le f_{G1} / f_{G1} \le 10.00$$
 (41)

Moreover, it is more preferable that the following conditional expression (41") is satisfied instead of conditional 50 expression (41).

$$1.00 < f_{G1} / f_{G1} < 7.00$$
 (41")

Furthermore, it is even more preferable that the following conditional expression (41"") is satisfied instead of condi-

$$1.67 < f_{G1} / f_{G1} < 5.00$$
 (41"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (42) 60 is satisfied:

$$0.01 \le 1/\nu d_{G1min} - 1/\nu d_{G1max}$$
 (42)

 vd_{G1min} denotes a smallest Abbe's number from among 65 Abbe's numbers for lenses forming the first lens unit, and

 vd_{G1max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the first lens unit.

In the optical system according to the present embodiment, it is preferable that the following (i) and (ii) have been realized. (i) Enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, (ii) Favorable correction of the longitudinal chromatic aberration and the chromatic aberration of magnification. Conditional expression (42) is an expression for achieving both of (i) and (ii).

By making so as not to fall below a lower limit value of conditional expression (42), it is possible to suppress the 10 occurrence of the longitudinal chromatic aberration in the first lens unit. Moreover, as it is possible to suppress the occurrence of the longitudinal chromatic aberration in the first lens unit, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. Accordingly, since the correction of the chromatic aberration of magnification in the second lens unit can be carried out favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

Here, it is preferable that the following conditional expression (42') is satisfied instead of conditional expression (42).

$$0.011 < 1/vd_{G1min} - 1/vd_{G1max}$$
 (42')

Moreover, it is more preferable that the following conditional expression (42") is satisfied instead of conditional expression (42).

$$0.014 < 1/\nu d_{G1min} - 1/\nu d_{G1max}$$
 (42")

Furthermore, it is even more preferable that the following 30 conditional expression (42") is satisfied instead of conditional expression (42).

$$0.020 < 1/v d_{G1min} - 1/v d_{G1max}$$
 (42"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (43) is satisfied:

$$0.01 \le 1/v d_{G2min} - 1/v d_{G2max}$$
 (43)

where,

 $\operatorname{vd}_{G2min}$ denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and $\operatorname{vd}_{G2max}$ denotes a largest Abbe's number from among Abbe's numbers for lenses forming the second lens unit.

In the optical system according to the present embodiment, it is preferable that the aforementioned (i) and (ii) have been realized. Conditional expression (43) is an expression for achieving both of (i) and (ii).

By making so as not to fall below a lower limit value of conditional expression (43), it is possible to suppress the occurrence of the longitudinal chromatic aberration in the second lens unit. Moreover, as it is possible to suppress the occurrence of the longitudinal chromatic aberration in the second lens unit, an excessive correction of the longitudinal chromatic aberration in the first lens unit becomes unnecessary. Accordingly, since the correction of the chromatic aberration of magnification in the second lens unit can be carried out favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

Here, it is preferable that the following conditional expression (43') is satisfied instead of conditional expression (43).

$$0.011 < 1/vd_{G2min} - 1/vd_{G2max}$$
 (43')

Moreover, it is more preferable that the following conditional expression (43") is satisfied instead of conditional expression ((43).

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Furthermore, it is even more preferable that the following conditional expression (43") is satisfied instead of conditional expression (43).

$$0.020 < 1/\nu d_{G2min} - 1/\nu d_{G2max}$$
 (43")

It is preferable that the optical system according to the present embodiment includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where,

 θ_{gF} denotes a partial dispersion ratio of the positive lens, and is expressed by θ_{gF} =(ng-nF)/(nF-nC), where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

In the optical system according to the present embodiment, it is preferable that the aforementioned (i) and (ii) have been realized. Conditional expression (44) is an expression for achieving both of (i) and (ii).

When the longitudinal chromatic aberration and the chromatic aberration of magnification for the d-line and the C-line have been corrected favorably, by disposing the positive lens satisfying conditional expression (44) in the optical system, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification for the g-line favorably.

A material satisfying conditional expression (44), in many cases, is a material having a high dispersion in general. Therefore, using a material which satisfies conditional expression (44) for a lens having a positive refractive power means imparting a function of correcting a chromatic aberration which is opposite to a usual case, to the lens. However, in a case of carrying out more favorable correction of chromatic aberration, it is desirable to use a material which satisfies conditional expression (44), for the lens having a positive refractive power.

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the lens satisfying conditional expression (44) is included in the first lens unit.

When an attempt is made to secure an appropriate working distance in the optical system, in many cases, an aberration in the first lens unit is outspread to the second lens unit. Therefore, it is desirable to correct favorably the chromatic aberration for the g-line solely in the first lens unit. By doing so, it is possible to correct the chromatic aberration for the g-line favorably, solely in the first lens unit.

In the optical system according to the present embodiment, it is preferable that the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s}/L_{G1s} \le 1$$
 (45)

where

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 ${\rm D}_{p1s}$ denotes a distance on the optical axis from an object-side surface of the positive lens up to the stop, and

 L_{G1s} denotes a distance on the optical axis from an object-side surface of the first object-side lens up to the stop.

By satisfying conditional expression (45), it is possible to position the principal point of the first lens unit on the object side while correcting the chromatic aberration favorably. As a result, small-sizing of the optical system is possible while securing the working distance to a fixed amount.

Here, it is preferable that the following conditional expression (45') is satisfied instead of conditional expression (45).

Moreover, it is more preferable that the following conditional expression (45") is satisfied instead of conditional expression (45).

$$0.50 < D_{p1s}/L_{G1s} \le 1.00$$
 (45")

Furthermore, it is even more preferable that the following conditional expression (45") is satisfied instead of conditional expression (45).

$$0.70 < D_{p1s} / L_{G1s} \le 1.00$$
 (45")

In the optical system according to the present embodiment, it is preferable that the first lens unit includes not less than two negative lenses that satisfy the following conditional expression (46):

$$0.01 < 1/v d_{G1n} - 1/v d_{G1max}$$
(46)

 vd_{G1n} denotes a smallest Abbe's number for the negative lens forming the first lens unit, and

Abbe's numbers for lenses forming the first lens unit.

By satisfying conditional expression (46), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably. Two or more than two negative lenses which satisfy conditional 25 expression (46), or in other words, two or more than two negative lenses which have a function of correcting the chromatic aberration are used, and are disposed to have an appropriate positional relation. Accordingly, when the occurrence of the longitudinal chromatic aberration in the first lens unit has been suppressed, it is possible to correct the chromatic aberration of magnification in the first lens unit favorably. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification in the overall optical system favorably. Particularly, in a case of 35 a magnifying optical system, for correcting the chromatic aberration of magnification in the first lens unit favorably, it is desirable to satisfy conditional expression (46).

Moreover, in the optical system according to the present embodiment, it is preferable that the two or more than two 40 negative lenses which satisfy conditional expression (46) include an object-side negative lens which is disposed nearest to the object, and an image-side negative lens which is disposed nearest to the image, and the object-side negative lens satisfies the following conditional expression (47):

$$0.2 < D_{non}/L_{G1s} < 0.9$$
 (47)

 D_{noni} denotes a distance on the optical axis from an objectside surface of the object-side negative lens up to an object- 50 side surface of the image-side negative lens, and

 L_{G1s} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the stop.

By satisfying conditional expression (47), it is possible to correct the longitudinal chromatic aberration and the chro- 55 matic aberration of magnification more favorably. Two or more than two negative lenses which satisfy conditional expression (46), or in other words, two or more than to negative lenses having a function of correcting the chromatic aberration are used, and these negative lenses are disposed at 60 positions which satisfy conditional expression (47). Accordingly, when the occurrence of the longitudinal chromatic aberration in the first lens unit has been suppressed, it is possible to correct the chromatic aberration of magnification in the first lens unit more favorably. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification of the overall lens system

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more favorably. Particularly, in a case of a magnifying optical system, for correcting the chromatic aberration of magnification in the first lens unit favorably, it is desirable to satisfy conditional expression (47).

Here, it is preferable that the following conditional expression (47') is satisfied instead of conditional expression (47).

$$0.21 < D_{noni}/L_{G1s} < 0.86$$
 (47')

Moreover, it is more preferable that the following condi-10 tional expression (47") is satisfied instead of conditional expression (47).

$$0.22 < D_{non} / L_{G1s} < 0.81$$
 (47")

Furthermore, it is even more preferable that the following 15 conditional expression (47"") is satisfied instead of conditional expression (47).

$$0.23 < D_{noni}/L_{G1s} < 0.77$$
 (47")

In the optical system according to the present embodiment, vd_{G1max} denotes a largest Abbe's number from among 20 it is preferable that the first lens unit has a positive refractive power, and includes at least one diffractive optical element.

> A height of an axial marginal ray is high in the first lens unit. Therefore, by letting the refractive power of the first lens unit to be a positive refractive power, and disposing the diffractive optical element in the first lens unit, it is possible to suppress the occurrence of the longitudinal chromatic aberration in the first lens unit.

> In the optical system according to the present embodiment, it is preferable to dispose at least one diffractive optical element at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 < D_{DLs}/D_{Glis} \tag{48}$$

where.

D_{DLs} denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 D_{Glis} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop.

At the position in the first lens unit at which, conditional expression (48) is satisfied, since the height of the principal ray becomes comparatively higher, by disposing the diffractive optical element at that position, it is possible to correct the chromatic aberration of magnification for the F-line and the g-line in particular, more favorably. To be more precise, D_{DLs} is a distance from a diffractive surface of the diffractive optical element up to the stop.

In the optical system according to the present embodiment, it is preferable to dispose at least one diffractive optical element at a position which is on the image side of the stop, and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

 \mathbf{D}_{sDL} denotes a distance on the optical axis from the stop up to the diffractive optical element, and

 L_{sG} denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens.

At the position in the second lens unit at which, conditional expression (49) is satisfied, since the height of the principal ray becomes comparatively higher, by disposing the diffractive optical element at that position, it is possible to correct the chromatic aberration of magnification for the F-line and the g-line in particular, more favorably. To be more precise, D_{sDL} is a distance from the stop up to a diffractive surface of the diffractive optical element.

Here, it is preferable that the following conditional expression (49') is satisfied instead of conditional expression (49).

$$0.21 < D_{sDL}/L_{sG2} < 0.86$$
 (49')

Moreover, it is more preferable that the following conditional expression (49") is satisfied instead of conditional expression (49).

$$0.22 < D_{sDL}/L_{sG2} < 0.86$$
 (49")

Furthermore, it is even more preferable that the following 10 conditional expression (49") is satisfied instead of conditional expression (49).

$$0.23 < D_{sDL}/L_{sG2} < 0.86$$
 (49")

Moreover, it is preferable that the optical system according to the present embodiment includes a negative lens which satisfies the following conditional expressions (50) and (51):

$$0.01 < 1/v d_{n1} - 1/v d_{G1max}$$
 (50)

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51) 20

where,

 vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 D_{n1s} denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 D_{os} denotes a distance on the optical axis from the object up to the stop.

For achieving both, shortening of the overall length of the optical system and favorable correction of the chromatic aberration and the curvature of field, it is preferable to satisfy conditional expressions (50) and (51).

By making so as not to fall below lower limit values of conditional expression (50) and (51), it is possible to secure a thickness of the negative lens appropriately.

By making so as not to exceed an upper limit values of conditional expressions (50) and (51), it is possible to dispose the negative lens having a function of correcting the chromatic aberration because of high dispersion, near the stop. The height of an axial marginal ray being low near the stop, it is possible to correct favorably the chromatic aberration and the curvature of field simultaneously by the negative lens.

Here, it is preferable that the following conditional expression (51') is satisfied instead of conditional expression (51).

$$0.01 < D_{n1s}/D_{os} < 0.29$$
 (51')

Moreover, it is more preferable that the following conditional expression (51") is satisfied instead of conditional expression (51).

$$0.02 < D_{n1} < D_{os} < 0.27$$
 (51")

Furthermore, it is even more preferable that the following conditional expression (51") is satisfied instead of conditional expression (51).

$$0.03 < D_{n1s}/D_{os} < 0.26$$
 (51"")

It is preferable that the optical system according to the present embodiment includes a negative lens which satisfies the following conditional expressions (52) and (53):

$$0.01 < 1/v d_{n2} - 1/v d_{G2max} \tag{52}$$

$$0 < D_{sn2} / D_{si} < 0.4$$
 (53)

where,

 vd_{n2} denotes Abbe's number for the negative lens,

 vd_{G2max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the second lens unit,

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 ${\rm D}_{sn2}$ denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 D_{si} denotes a distance on the optical axis from the stop up to the image.

For achieving both, shortening of the overall length of the optical system and favorable correction of the chromatic aberration and the curvature of field, it is preferable to satisfy conditional expressions (52) and (53).

By making so as not to fall below lower limit values of conditional expressions (52) and (53), it is possible to secure a thickness of the negative lens appropriately.

By making so as not to exceed an upper limit values of conditional expressions (52) and (53), it is possible to dispose the negative lens having a function of correcting the chromatic aberration because of high dispersion, near the stop. The height of an axial marginal ray being low near the stop, it is possible to correct favorably the chromatic aberration and the curvature of field simultaneously by the negative lens.

Here, it is preferable that the following conditional expression (53') is satisfied instead of conditional expression (53).

$$0.01 < D_{sn2}/D_{si} < 0.38$$
 (53')

Moreover, it is more preferable that the following conditional expression (53") is satisfied instead of conditional expression (53).

$$0.02 < D_{sn2}/D_{si} < 0.36$$
 (53")

Furthermore, it is even more preferable that the following conditional expression (53") is satisfied instead of conditional expression (53).

$$0.03 < D_{sp2}/D_{si} < 0.34$$
 (53"')

It is preferable that the optical system according to the present embodiment includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn3} / D_{si} < 1$$
 (54)

where,

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 D_{sn3} denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 D_{st} denotes a distance on the optical axis from the stop up to the image.

For achieving both, shortening of the overall length of the optical system and favorable correction of the off-axis aberration such as the chromatic aberration of magnification, it is preferable to satisfy conditional expression (54).

By making so as not to fall below a lower limit value of conditional expression (54), in the second lens unit, it is possible to dispose the negative lens in a region closer to the image side. Accordingly, since it is possible to position the principal point on the object side, even if the overall length of the optical system is shortened, it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually. As a result it is possible to correct favorably the chromatic aberration of magnification in particular.

By making so as not to exceed an upper limit value of conditional expression (54), it is possible to increase a distance between the negative lens and the image pickup element. Therefore, even when a ghost is generated due to multiple reflection between the negative lens and the image pickup element, it is possible to prevent the ghost from being incident on a surface of the image pickup element with a high density.

Here, it is preferable that the following conditional expression (54') is satisfied instead of conditional expression (54).

$$0.63 < D_{sn3}/D_{si} < 0.98$$
 (54')

Moreover, it is more preferable that the following conditional expression (54") is satisfied instead of conditional expression (54).

$$0.66 < D_{sn3}/D_{si} < 0.96$$
 (54")

Furthermore, it is even more preferable that the following conditional expression (54"") is satisfied instead of conditional expression (54).

$$0.70 < D_{sn3}/D_{si} < 0.94$$
 (54"")

It is preferable that the optical system according to the present embodiment includes a positive lens at a position which satisfies the following conditional expression (55):

$$0.3 < D_{p2s}/D_{os} < 0.99$$
 (55)

where.

 D_{p2s} denotes a distance on the optical axis from an objectside surface of the positive lens up to the stop, and

D_{as} denotes a distance on the optical axis from object up to

For achieving both, shortening of the overall length of the optical system and favorable correction of the chromatic 25 aberration of magnification and the off-axis aberration, it is preferable to satisfy conditional expression (55).

By making so as not to fall below a lower limit value of conditional expression (55), it is possible to dispose the positive lens on the object side. Accordingly, since it is possible to position the principal point of the first lens unit on the object side, it is possible to secure an appropriate working distance.

By making so as not to exceed an upper limit value of conditional expression (55), it is possible to prevent the positive lens from coming too close to the object. As a result it is 35 possible to secure an appropriate working distance.

Here, it is preferable that the following conditional expression (55) is satisfied instead of conditional expression (55).

$$0.35 < D_{v3} / D_{cc} < 0.89$$
 (55')

Moreover, it is more preferable that the following conditional expression (55") is satisfied instead of conditional expression (55).

$$0.42 < D_{p2s}/D_{os} < 0.80$$
 (55") 45

Furthermore, it is even more preferable that the following conditional expression (55") is satisfied instead of conditional expression (55).

$$0.49 < D_{p2s}/D_{os} < 0.70$$
 (55"")

In the optical system according to the eighth embodiment, it is preferable that, instead of conditional expression (55), the following conditional expression (55-1) is satisfied.

$$0.3 < D_{p2s}/D_{os} < 0.7$$
 (55-1)

In the optical system according to the ninth embodiment, it is preferable that, instead of conditional expression (55), the following conditional expression (55-2) is satisfied.

$$0.5 < D_{p2s}/D_{os} < 0.99$$
 (55-2)

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and that the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

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where.

 L_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens,

 D_{oi} denotes a distance on the optical axis from the object up to the image,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the image.

By making so as not to fall below a lower limit value of conditional expression (56), even in an optical system of which, the overall length is shortened, since it becomes possible to change the height of a principal ray emerged from a periphery of the object and reaching a periphery of the image comparatively gradually, it is possible to prevent the radius of curvature of a lens in the optical system from becoming excessively small. As a result, it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification.

By satisfying conditional expressions (16), (19), (20), and (56), it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification more effectively while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (25) and (56), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing the working distance appropriately, and carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (56') is satisfied instead of conditional expression (56).

$$0.87 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56')

Moreover, it is more preferable that the following conditional expression (56") is satisfied instead of conditional expression (56).

$$0.96 < L_I/D_{oi} + 0.07 \times WD/BF$$
 (56")

Furthermore, it is even more preferable that the following conditional expression (56") is satisfied instead of conditional expression (56).

$$1.07 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56"')

Moreover, in the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (57) is satisfied:

$$D_{os}/L_{GI}$$
 = 0.39×WD/BF<1.8 (57)

D_{os} denotes a distance on the optical axis from the object up 55 to the stop,

 L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the image.

By making so as not to exceed an upper limit value of conditional expression (57), even in an optical system of which, the overall length is shortened, it becomes possible to change the height of a principal ray emerged from a periphery of the object and reaching a periphery of the image compara-

tively gradually, and it is possible to prevent the radius of curvature of a lens in the optical system from becoming excessively small. Therefore, it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification.

By satisfying conditional expressions (16), (19), (20), and (57), it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification more effectively while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (25) and (57), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing the working distance appropriately, and carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (57') is satisfied instead of conditional expression (57).

$$D_{os}/L_{G1}$$
=0.39×WD/BF<1.53 (57')

Moreover, it is more preferable that the following conditional expression (57") is satisfied instead of conditional expression (57).

$$D_{os}/L_{G1}$$
-0.39×*WD/BF*<1.40 (57")

Furthermore, it is even more preferable that the following conditional expression (57") is satisfied instead of conditional expression (57).

$$D_{os}/L_{G1}$$
=0.39×WD/BF<1.30 (57"")

Moreover, an image pickup apparatus of the present embodiment is characterized by including the abovementioned optical system and the image pickup element.

Moreover, an image pickup system of the present embodi- 35 ment is characterized by including the image pickup apparatus, a stage which holds an object, and an illuminating unit which illuminates the object.

By illuminating the object by the illuminating unit, since it is possible to reduce a noise at the time of image pickup, it is 40 lenses from the lens L1 to the lens L10. possible to acquire an image with a high resolution.

Moreover, in the image pickup system of the present embodiment, it is preferable that the image pickup apparatus and the stage are integrated.

Since the numerical aperture on the object side of the 45 optical system according to the present embodiment is large, the optical system has a high resolution, but a depth of field becomes shallow. Therefore, in the image pickup system using the optical system according to the present embodiment, it is preferable to integrate the image pickup apparatus 50 and the stage which holds the object. By integrating the image pickup apparatus and the stage, since it is possible to maintain relative positions and a relative distance of the image pickup apparatus and the object to be fixed, it is possible to acquire an image with a high resolution.

Regarding each conditional expression, by restricting one of or both an upper limit value and a lower limit value, since it is possible to make that function more assured, it is preferable to apply restriction. Moreover, regarding each conditional expression, only an upper limit value or a lower limit 60 value of a numerical range of a further restricted conditional expression may be restricted. Moreover, with regard to restricting the numerical range of a conditional expression, the upper limit value or the lower limit value of each conditional expression described above may be an upper limit value or a lower limit value of a conditional expression other than those described above.

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An optical system according to an example 1 will be described below. FIG. 1 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 1. Moreover, FIG. 2A, FIG. 2B, FIG. 2C, and FIG. 2D are aberration diagrams of the optical system according to the example 1.

In the aberration diagrams shown in FIG. 2A, FIG. 2B, FIG. 2C, and FIG. 2D, 'FIY' denotes the maximum image height. Symbols in the aberration diagrams are same even in examples that will be described later. Moreover, in aberration diagrams of examples from the example 1 to an example 7, four aberration diagrams in order from left show a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC).

The optical system according to the example 1, as shown in FIG. 1, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. In the 20 examples from the example 1 to the example 7, in lens crosssectional views, I denotes an image pickup surface of an image pickup element. The optical system according to the example 1 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.6 μm to 1.2 μm.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a biconcave negative lens L4, and a positive meniscus lens L5 having a convex surface directed toward the object side.

The lens unit Gr includes a positive meniscus lens L6 having a convex surface directed toward the image side, a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, and the biconvex positive lens L10.

The aperture stop S is disposed between the lens L5 and the

An aspheric surface is provided to both surfaces of all the

The optical system according to the example 1 includes five pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L10, the lens L2 and the lens L9, the lens L3 and the lens L8, the lens L4 and the lens L7, and the lens L5 and the lens L6. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 2 of the present invention will be described below. FIG. 3 is a crosssectional view along an optical axis showing an optical arrangement of the optical system according to the example 2. Moreover, FIG. 4A, FIG. 4B, FIG. 4C, and FIG. 4D are aberration diagrams of the optical system according to the example 2.

The optical system according to the example 2, as shown in FIG. 3, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 2 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.6 μm to 1.2 μm.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a biconcave negative lens L4, and a positive meniscus lens L5 having a convex surface directed toward the object side.

The lens unit Gr includes a positive meniscus lens L6 having a convex surface directed toward the image side, a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, and the biconvex positive lens L10.

The aperture stop S is disposed between the lens $L\mathbf{5}$ and the lens $L\mathbf{6}$.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L10.

The optical system according to the example 2 includes five pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L10, the lens L2 and the lens L9, the lens L3 and the lens L8, the lens L4 and the lens L7, and the lens L5 and the lens L6. I5 Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair differ slightly.

Next, an optical system according to an example 3 will be described below. FIG. 5 is a cross-sectional view along an optical axis showing an optical arrangement of the optical 20 system according to the example 3. Moreover, FIG. 6A, FIG. 6B, FIG. 6C, and FIG. 6D are aberration diagrams of the optical system according to the example 3.

The optical system according to the example 3, as shown in FIG. 5, includes in order from an object side, a lens unit Gf $\,^2$ 5 having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 3 is suitable for an image pickup element for which, a pixel pitch is in a range of $0.6 \, \mu m$ to $1.2 \, \mu m$.

The lens unit Gf includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward an image side, a negative meniscus lens L3 having a convex surface directed toward the object side, a negative meniscus lens L4 having a convex surface directed toward the 35 image side, a biconcave negative lens L5, and a positive meniscus lens L6 having a convex surface directed toward the object side.

The lens unit Gr includes a positive meniscus lens L7 having a convex surface directed toward the image side, a 40 biconcave negative lens L8, a negative meniscus lens L9 having a convex surface directed toward the object side, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the object side, and a biconvex positive lens L12.

The aperture stop S is disposed between the lens L6 and the lens L7.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L12.

The optical system according to the example 3 includes six pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L12, the lens L2 and the lens L11, the lens L3 and the lens L10, the lens L4 and the lens L9, the lens L5 and the lens L8, and the (55) lens L6 and the lens L7. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 4 of the present invention will be described below. FIG. **7** is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 4. Moreover, FIG. **8**A, FIG. **8**B, FIG. **8**C, and FIG. **8**D are aberration diagrams of the optical system according to the example 4.

The optical system according to the example 4, as shown in FIG. 7, includes in order from an object side, a lens unit Gf

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having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 4 is suitable for an image pickup element for which, a pixel pitch is in a range of $0.6\,\mu m$ to $1.2\,\mu m$.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a negative meniscus lens L4 having a convex surface directed toward the object side, and a biconvex positive lens L5.

The lens unit Gr includes a biconvex positive lens L6, a negative meniscus lens L7 having a convex surface directed toward the image side, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, a negative meniscus lens L10 having a convex surface directed toward the image side, and a biconvex positive lens L11.

The aperture stop S is disposed between the lens L5 and the lens L6.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L11.

The optical system according to the example 4 includes four pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L1, the lens L3 and the lens L8, the lens L4 and the lens L7, and the lens L5 and the lens L6. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 5 will be described below. FIG. 9 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 5. Moreover, FIG. 10A, FIG. 10B, FIG. 10C, and FIG. 10D are aberration diagrams of the optical system according to the example 5.

The optical system according to the example 5, as shown in FIG. 9, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 5 is suitable for an image pickup element for which, a pixel pitch is in a range of $1.0 \, \mu m$ to $1.6 \, \mu m$.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a negative meniscus lens L4 having a convex surface directed toward the object side, and a biconvex positive lens L5.

The lens unit Gr includes a biconvex positive lens L6, a negative meniscus lens L7 having a convex surface directed toward the image side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the image side, a biconcave negative lens L10, and a biconvex positive lens L11.

The aperture stop S is disposed between the lens L5 and the lens L6.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L11.

The optical system according to the example 5 includes two pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L3 and the lens L8, and the lens L5 and the lens L6. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 6 will be described below. FIG. 11 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 6. Moreover, FIG. 12A, FIG. 12B, FIG. 12C, and FIG. 12D are aberration diagrams of 5 the optical system according to the example 6.

The optical system according to the example 6, as shown in FIG. 11, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 6 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.9 μm to 1.5 μm.

The lens unit Gf includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 15 positive meniscus lens L2 having a convex surface directed toward the object side, a biconcave negative lens L3, and a biconvex positive lens L4.

The lens unit Gr includes a biconvex positive lens L5, a biconcave negative lens L6, a positive meniscus lens L7 hav- 20 ing a convex surface directed toward the image side, and a biconcave negative lens L8.

The aperture stop S is positioned on the image side of the biconvex positive lens L4, and on the object side of a vertex of the image-side surface of the biconvex positive lens L4.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L8.

The optical system according to the example 6 does not include a pair of lenses which satisfies conditional expressions (1), (2), and (3).

Next, an optical system according to an example 7 will be described below. FIG. 13 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 7. Moreover, FIG. 14A, the optical system according to the example 7.

The optical system according to the example 7, as shown in FIG. 13, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical 40 system according to the example 7 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.7 μm to 1.3 μm.

The lens unit Gf includes a biconcave negative lens L1, a positive meniscus lens L2 having a convex surface directed 45 toward the object side, a biconcave negative lens L3, and a biconvex positive lens L4.

The lens unit Gr includes a biconvex positive lens L5, a biconcave negative lens L6, a positive meniscus lens L7 having a convex surface directed toward an image side, and a 50 negative meniscus lens L8 having a convex surface directed toward the object side.

The aperture stop S is positioned on the object side of the biconvex positive lens L5, and on the object side of a vertex of the object-side surface of the biconvex positive lens L5.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L8.

The optical system according to the example 7 does not include a pair of lenses which satisfies conditional expressions (1), (2), and (3).

In some of the following examples, a diffractive optical element is used. The diffractive optical element used here is an optical element as described in Japanese Patent Publication No. 3717555 in which, at least two layers of mutually different optical materials are laminated and a relief pattern is 65 formed at an interface thereof, and a diffraction efficiency is made higher in a wide wavelength region. However, the dif72

fractive optical element to be used in the optical element of the examples is not restricted to such diffractive optical element, and may be a diffractive optical element described in Japanese Patent Application Laid-open Publication No. 2003-215457 and Japanese Patent Application Laid-open publication No. Hei 11-133305.

Next, an optical system according to an example 8 will be described below. FIG. 15A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 8. Moreover, FIG. 15B, FIG. 15C, FIG. 15D, and FIG. 15E are aberration diagrams of the optical system according to the example 8.

In the aberration diagrams shown in FIG. 15B, FIG. 15C, FIG. 15D, and FIG. 15E, 'FIY' denotes the maximum image height. Symbols in the aberration diagrams are same even in examples that will be described later. Moreover, in aberration diagrams of examples from the example 8 to an example 96, four aberration diagrams in order from left show a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC).

The optical system according to the example 8, as shown in FIG. 15A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. In the examples from the example 8 to the example 96, in lens cross-sectional views, S denotes a stop, C denotes a cover glass, and I denotes an image pickup surface of an image pickup element.

The first lens unit G1 includes a biconvex positive lens L1, 30 a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens FIG. 14B, FIG. 14C, and FIG. 14D are aberration diagrams of 35 L5 having a convex surface directed toward an image side, a positive meniscus lens L6 having a convex surface directed toward the image side, a positive meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, and a biconcave negative lens L9. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L9.

> The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

> An aspheric surface is provided to seven surfaces namely, a surface on the image side of the positive meniscus lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the biconvex positive lens L8, and both surfaces of the biconcave negative lens L9.

Next, an optical system according to an example 9 will be described below. FIG. 16A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 9. Moreover, FIG. 16B, FIG. **16**C, FIG. **16**D, and FIG. **16**E are aberration diagrams of the 55 optical system according to the example 9.

The optical system according to the example 9, as shown in FIG. 16A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward an image side, a positive meniscus lens L7 having a convex surface directed

toward the image side, a biconvex positive lens L8, a biconvex positive lens L9, and a biconcave negative lens L10. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10.

The aperture stop S is disposed between the biconcave negative lens $L\mathbf{5}$ and the negative meniscus lens $L\mathbf{6}$.

An aspheric surface is provided to nine surfaces namely, both surfaces of the biconcave negative lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex positive lens L9, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 10 will be described below. FIG. 17A is a cross-sectional view along an 15 optical axis showing an optical arrangement of the optical system according to the example 10. Moreover, FIG. 17B, FIG. 17C, FIG. 17D, and FIG. 17E are aberration diagrams of the optical system according to the example 10.

The optical system according to the example 10, as shown 20 in FIG. 17A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed 25 toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward an image side, a 30 positive meniscus lens L6 having a convex surface directed toward the image side, a biconvex positive lens L7, a biconcave negative lens L8, a biconvex positive lens L9, and a negative meniscus lens L10 having a convex surface directed toward the image side. The negative meniscus lens L5 and the 35 positive meniscus lens L6 are cemented. Moreover the biconvex positive lens L7 and the biconcave negative lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L10.

The aperture stop S is disposed between the biconcave 40 negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to five surfaces namely, a surface on the image side of the positive meniscus lens L2, both surfaces of the biconvex positive lens L9, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 11 will be described below. FIG. **18**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 11. Moreover, FIG. **18**B, FIG. **18**C, FIG. **18**D, and FIG. **18**E are aberration diagrams of 50 the optical system according to the example 11.

The optical system according to the example 11, as shown in FIG. **18**A, includes in order from an object side, a first lens unit G**1** having a positive refractive power, an aperture stop S, and a second lens unit G**2** having a positive refractive power. 55

The first lens unit G1 includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a biconvex positive lens L7, a biconvex positive lens L8, a biconcave negative lens L9, and a biconcave negative lens L10. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. Moreover, the

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biconvex positive lens L8 and the biconcave negative lens L9 are cemented. A predetermined lens unit includes the biconcave negative lens L10.

The aperture stop S is disposed between the biconcave 5 negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to five surfaces namely, a surface on an image side of the positive meniscus lens L2, both surfaces of the biconvex positive lens L7, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 12 will be described below. FIG. 19A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 12. Moreover, FIG. 19B, FIG. 19C, FIG. 19D, and FIG. 19E are aberration diagrams of the optical system according to the example 12.

The optical system according to the example 12, as shown in FIG. 19A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a positive meniscus lens L10 having a convex surface directed toward the object side, and a biconcave negative lens L11. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 10 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L9, both surfaces of the positive meniscus lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 13 will be described below. FIG. **20**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 13. Moreover, FIG. **20**B, FIG. **20**C, FIG. **20**D, and FIG. **20**E are aberration diagrams of the optical system according to the example 13.

The optical system according to the example 13, as shown in FIG. **20**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconvex positive lens L7, a biconcave negative lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, a positive meniscus lens L10 having a convex surface directed toward the object side, and a biconcave negative lens L11. A predetermined lens unit includes the biconcave negative lens

The aperture stop S is disposed between the biconcave negative lens L6 and the biconvex positive lens L7.

An aspheric surface is provided to 10 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L9, both surfaces of the positive meniscus lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 14 will be described below. FIG. 21A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 14. Moreover, FIG. 21B, FIG. 21C, FIG. 21D, and FIG. 21E are aberration diagrams of the optical system according to the example 14.

The optical system according to the example 14, as shown in FIG. 21A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a $_{20}$ biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a 25 biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, and a biconcave negative lens L10. A predetermined lens unit includes the biconcave negative lens L10.

The aperture stop S is disposed between the biconcave 30 negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 10 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 15 will be described below. FIG. **22**A is a cross-sectional view along an 40 optical axis showing an optical arrangement of the optical system according to the example 15. Moreover, FIG. **22**B, FIG. **22**C, FIG. **22**D, and FIG. **22**E are aberration diagrams of the optical system according to the example 15.

The optical system according to the example 15, as shown 45 in FIG. 22A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward the object side, a 50 biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens 55 L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconcave negative lens L10, and a biconcave negative lens L11. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 11 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on an 65 image side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex

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positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 16 will be described below. FIG. 23A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 16. Moreover, FIG. 23B, FIG. 23C, FIG. 23D, and FIG. 23E are aberration diagrams of the optical system according to the example 16.

The optical system according to the example 16, as shown in FIG. 23A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward the object side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconvex positive lens L9, and a biconcave negative lens L10. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes a biconcave negative lens L10.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to nine surfaces namely, both surfaces of the positive meniscus lens L1, a surface on an image side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex positive lens L9, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 17 will be described below. FIG. 24A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 17. Moreover, FIG. 24B, FIG. 24C, FIG. 24D, and FIG. 24E are aberration diagrams of the optical system according to the example 17.

The optical system according to the example 17, as shown in FIG. 24A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconvex positive lens L2, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward an image side, a positive meniscus lens L6 having a convex surface directed toward the image side, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, and a biconcave negative lens L9. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes a biconcave negative lens L9.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to seven surfaces namely, a surface on the image side of the biconvex positive lens L2, both surfaces of the biconvex positive lens L7, both surfaces of the positive meniscus lens L8, and both surfaces of the biconcave negative lens L9.

Next, an optical system according to an example 18 will be described below. FIG. 25A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 18. Moreover, FIG. 25B,

FIG. 25C, FIG. 25D, and FIG. 25E are aberration diagrams of the optical system according to the example 18.

The optical system according to the example 18, as shown in FIG. 25A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 5 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 10 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a biconvex positive lens L7, a positive 15 meniscus lens L8 having a convex surface directed toward an image side, a biconcave negative lens L9, and a negative meniscus lens L10 having a convex surface directed toward the image side. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens 20 unit includes the biconcave negative lens L9 and the negative meniscus lens L10.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to five surfaces namely, a 25 surface on the image side of the positive meniscus lens L2, both surfaces of the biconvex positive lens L7, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 19 will be described below. FIG. 26A is a cross-sectional view along an 30 optical axis showing an optical arrangement of the optical system according to the example 19. Moreover, FIG. 26B, FIG. 26C, FIG. 26D, and FIG. 26E are aberration diagrams of the optical system according to the example 19.

The optical system according to the example 19, as shown 35 in FIG. 26A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a diffractive optical element DL, a biconvex positive lens L1, a positive meniscus lens L2 40 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens 45 L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a negative meniscus lens L8 having a convex surface directed toward an 50 image side, a biconvex positive lens L9, a biconcave negative lens L10, and a biconcave negative lens L11. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward the object side and a negative meniscus lens having a tern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to 12 surfaces namely, a surface on the object side of the biconvex positive lens L1, a 78

surface on the image side of the positive meniscus lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the negative meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens

Next, an optical system according to an example 20 will be described below. FIG. 27A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 20. Moreover, FIG. 27B, FIG. 27C, FIG. 27D, and FIG. 27E are aberration diagrams of the optical system according to the example 20.

The optical system according to the example 20, as shown in FIG. 27A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward an image side, and a negative meniscus lens L12 having a convex surface directed toward the image side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11 and the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 16 surfaces namely, both surfaces of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 21 will be described below. FIG. 28A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 21. Moreover, FIG. 28B, FIG. 28C, FIG. 28D, and FIG. 28E are aberration diagrams of the optical system according to the example 21.

The optical system according to the example 21, as shown in FIG. 28A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed 55 toward the object side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens convex surface directed toward the object side. A relief pat- 60 L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a positive meniscus lens L11 having a convex surface directed toward the object side, a biconcave negative lens L12, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the positive meniscus

lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13 $\,$

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 16 surfaces namely, both surfaces of the biconvex positive lens L1, both surfaces of the negative meniscus lens L2, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the biconvex positive lens L4, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 22 will be 15 described below. FIG. **29**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 22. Moreover, FIG. **29**B, FIG. **29**C, FIG. **29**D, and FIG. **29**E are aberration diagrams of the optical system according to the example 22.

The optical system according to the example 22, as shown in FIG. 29A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 25 having a convex surface directed toward the object side, a negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave 30 negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed 35 toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens L13 having a convex surface directed toward an image side. The negative meniscus lens L7 and the positive meniscus lens L8 40 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 14 surfaces namely, both 45 surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 23 will be described below. FIG. **30**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical 55 system according to the example 23. Moreover, FIG. **30**B, FIG. **30**C, FIG. **30**D, and FIG. **30**E are aberration diagrams of the optical system according to the example 23.

The optical system according to the example 23, as shown in FIG. 30A, includes a first lens unit G1 having a positive 60 refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward the object side, a positive meniscus lens L2 having a convex surface directed 65 toward the object side, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex

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positive lens L4, a biconvex positive lens L5, a biconvex positive lens L6, and a biconcave negative lens L7. The negative meniscus lens L1 and the positive meniscus lens L2 are cemented. Moreover, the biconvex positive lens L6 and the biconcave negative lens L7 are cemented.

The second lens unit G2 includes a negative meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconcave negative lens L11, a biconvex positive lens L12, a biconcave negative lens L13, and a negative meniscus lens L14 having a convex surface directed toward an image side. The negative meniscus lens L8 and the positive meniscus lens L9 are cemented. A predetermined lens unit includes the biconcave negative lens L13 and the negative meniscus lens L14.

The aperture stop S is disposed between the biconcave negative lens L7 and the negative meniscus lens L8.

An aspheric surface is provided to 12 surfaces namely, a surface on the object side of the biconvex positive lens L4, a surface on the image side of the biconvex positive lens L5, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconcave negative lens L13, and both surfaces of the negative meniscus lens L14.

Next, an optical system according to an example 24 will be described below. FIG. 31A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 24. Moreover, FIG. 31B, FIG. 31C, FIG. 31D, and FIG. 31E are aberration diagrams of the optical system according to the example 24.

The optical system according to the example 24, as shown in FIG. 31A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens L13 having a convex surface directed toward the image side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 25 will be described below. FIG. 32A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 25. Moreover, FIG. 32B, FIG. 32C, FIG. 32D, and FIG. 32E are aberration diagrams of the optical system according to the example 25.

The optical system according to the example 25, as shown in FIG. 32A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a biconcave negative lens L13. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermine lens unit includes the biconcave negative lens L12 and the biconcave negative lens L13. 20

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object of the biconvex positive lens L3, a surface on the image 25 side of the biconvex positive lens L4, both surfaces of the positive meniscus lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 26 will be described below. FIG. 33A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 26. Moreover, FIG. 33B, FIG. 33C, FIG. 33D, and FIG. 33E are aberration diagrams of 35 the optical system according to the example 26.

The optical system according to the example 26, as shown in FIG. 33A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an object side, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a negative meniscus lens L6 having a convex surface directed toward the image side. The positive meniscus lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a 50 positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens L13 having a 55 convex surface directed toward the image side. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus L13.

The aperture stop S is disposed between the negative 60 meniscus lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the positive meniscus lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens

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L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 27 will be described below. FIG. 34A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 27. Moreover, FIG. 34B, FIG. 34C, FIG. 34D, and FIG. 34E are aberration diagrams of the optical system according to the example 27.

The optical system according to the example 27, as shown in FIG. 34A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex surface directed toward the image side. The positive meniscus lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward an object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconcave negative lens L9, a biconvex positive lens L10, a biconcave negative lens L11, and a negative meniscus lens L12 having a convex surface directed toward the image side. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the negative meniscus lens L12.

The aperture stop S is disposed between the negative meniscus lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 28 will be described below. FIG. 35A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 28. Moreover, FIG. 35B, FIG. 35C, FIG. 35D, and FIG. 35E are aberration diagrams of the optical system according to the example 28.

The optical system according to the example 28, as shown in FIG. 35A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex surface directed toward the image side. The positive meniscus lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L6 and the biconvex positive lens

L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12

The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the positive meniscus lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 29 will be described below. FIG. **36**A is a cross-sectional view along an 15 optical axis showing an optical arrangement of the optical system according to the example 29. Moreover, FIG. **36**B, FIG. **36**C, FIG. **36**D, and FIG. **36**E are aberration diagrams of the optical system according to the example 29.

The optical system according to the example 29, as shown 20 in FIG. **36**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a 25 positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex surface directed toward the image side. The positive meniscus 30 lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens 40 L12.

The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 45 object side of the positive meniscus lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and 50 both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 30 will be described below. FIG. 37A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 30. Moreover, FIG. 37B, 55 FIG. 37C, FIG. 37D, and FIG. 37E are aberration diagrams of the optical system according to the example 30.

The optical system according to the example 30, as shown in FIG. 37A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 60 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive 65 meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex

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surface directed toward the image side. The positive meniscus lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, and a biconcave negative lens L11. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the positive meniscus lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 31 will be described below. FIG. 38A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 31. Moreover, FIG. 38B, FIG. 38C, FIG. 38D, and FIG. 38E are aberration diagrams of the optical system according to the example 31.

The optical system according to the example 31, as shown in FIG. 38A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconcave negative lens L11, and a positive meniscus lens L12 having a convex surface directed toward the object side. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the positive meniscus lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the positive meniscus lens L2, a surface on an image side of the positive meniscus lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the positive meniscus lens L12.

Next, an optical system according to an example 32 will be described below. FIG. **39**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 32. Moreover, FIG. **39**B, FIG. **39**C, FIG. **39**D, and FIG. **39**E are aberration diagrams of the optical system according to the example 32.

The optical system according to the example 32, as shown in FIG. 39A, includes a first lens unit G1 having a positive

refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex 15 positive lens L9, a biconcave negative lens L10, and a positive meniscus lens L11 having a convex surface directed toward an image side. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the positive 20 meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 25 object side of the positive meniscus lens L2, a surface on the image side of the positive meniscus lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the positive meniscus lens L11.

Next, an optical system according to an example 33 will be described below. FIG. **40**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 33. Moreover, FIG. **40**B, FIG. **40**C, FIG. **40**D, and FIG. **40**E are aberration diagrams of 35 the optical system according to the example 33.

The optical system according to the example 33, as shown in FIG. 40A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave 45 negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed 50 toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermine lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an 60 image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 34 will be 65 described below. FIG. 41A is a cross-sectional view along an optical axis showing an optical arrangement of the optical

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system according to the example 34. Moreover, FIG. 41B, FIG. 41C, FIG. 41D, and FIG. 41E are aberration diagrams of the optical system according to the example 34.

The optical system according to the example 34, as shown in FIG. 41A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a biconcave negative lens L12, and a biconcave negative lens L13. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 15 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconvex negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconvex negative lens L12, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 35 will be described below. FIG. 42A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 35. Moreover, FIG. 42B, FIG. 42C, FIG. 42D, and FIG. 42E are aberration diagrams of the optical system according to the example 35.

The optical system according to the example 35, as shown in FIG. 42A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 36 will be described below. FIG. **43**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 36. Moreover, FIG. **43**B, FIG. **43**C, FIG. **43**D, and FIG. **43**E are aberration diagrams of 5 the optical system according to the example 36.

The optical system according to the example 36, as shown in FIG. 43A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a biconvex positive lens L10, and a biconcave negative lens L11. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 11 surfaces namely, a 25 surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 37 will be described below. FIG. **44**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 37. Moreover, FIG. **44**B, FIG. **44**C, FIG. **44**D, and FIG. **44**E are aberration diagrams of the optical system according to the example 37.

The optical system according to the example 37, as shown in FIG. 44A, includes a first lens unit G1 having a positive 40 refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a 45 biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a 50 biconvex positive lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the 55 biconcave negative lens L12 and the positive meniscus lens L13

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a 60 surface on an image side of the biconvex positive lens L1, both surfaces of the biconvex negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconvex negative lens L12.

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Next, an optical system according to an example 38 will be described below. FIG. **45**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 38. Moreover, FIG. **45**B, FIG. **45**C, FIG. **45**D, and FIG. **45**E are aberration diagrams of the optical system according to the example 38.

The optical system according to the example 38, as shown in FIG. 45A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. The predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12

Next, an optical system according to an example 39 will be described below. FIG. **46**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 39. Moreover, FIG. **46**B, FIG. **46**C, FIG. **46**D, and FIG. **46**E are aberration diagrams of the optical system according to the example 39.

The optical system according to the example 39, as shown in FIG. **46**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L5, and a negative meniscus lens L6 having a convex surface directed toward an image side. The biconvex positive lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a biconvex positive lens L7, a biconcave negative lens L8, a negative meniscus lens L9 having a convex surface directed toward the image side, a biconvex positive lens L10, and a biconcave negative lens L11. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the negative meniscus lens L6 and the biconvex positive lens L7.

An aspheric surface is provided to 10 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on an object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 40 will be described below. FIG. **47**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 40. Moreover, FIG. **47**B, FIG. **47**C, FIG. **47**D, and FIG. **47**E are aberration diagrams of 5 the optical system according to the example 40.

The optical system according to the example 40, as shown in FIG. 47A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L1 and the biconcave negative lens L2 are cemented. Moreover, 15 the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconvex positive lens L7, a biconcave negative lens L8, a negative meniscus lens L9 having a convex surface directed toward an image side, a 20 biconvex positive lens L10, and a biconcave negative lens L11. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave 25 negative lens L6 and the biconvex positive lens L7.

An aspheric surface is provided to 11 surfaces namely, a surface on an object side of the biconvex positive lens L1, a cemented surface of the biconvex positive lens L1 and the biconcave negative lens L2, a surface on the image side of the biconvex positive lens L3, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 41 will be described below. FIG. **48**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 41. Moreover, FIG. **48**B, FIG. **48**C, FIG. **48**D, and FIG. **48**E are aberration diagrams of 40 the optical system according to the example 41.

The optical system according to the example 41, as shown in FIG. 48A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an object side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The negative meniscus lens L1 50 and the biconvex positive lens L2 are cemented. Moreover, the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward the object side, a negative 60 meniscus lens L12 having a convex surface directed toward an image side, and a biconcave negative lens L13. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

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An aspheric surface is provided to eight surfaces namely, both surfaces of the biconcave negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 42 will be described below. FIG. **49**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 42. Moreover, FIG. **49**B, FIG. **49**C, FIG. **49**D, and FIG. **49**E are aberration diagrams of the optical system according to the example 42.

The optical system according to the example 42, as shown in FIG. **49**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an image side, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L1 and the negative meniscus lens L2 are cemented. Moreover, the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward an object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a negative meniscus lens L12 having a convex surface directed toward the object side, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to eight surfaces namely, both surfaces of the biconcave negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 43 will be described below. FIG. **50**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 43. Moreover, FIG. **50**B, FIG. **50**C, FIG. **50**D, and FIG. **50**E are aberration diagrams of the optical system according to the example 43.

The optical system according to the example 43, as shown in FIG. **50**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on 5 the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 44 will be described below. FIG. **51**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 44. Moreover, FIG. **51**B, 15 FIG. **51**C, FIG. **51**D, and FIG. **51**E are aberration diagrams of the optical system according to the example 44.

The optical system according to the example 44, as shown in FIG. 51A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 20 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed 30 toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on 40 the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 45 will be described below. FIG. **52**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 45. Moreover, FIG. **52**B, 50 FIG. **52**C, FIG. **52**D, and FIG. **52**E are aberration diagrams of the optical system according to the example 45.

The optical system according to the example 45, as shown in FIG. **52**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 55 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 60 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed 65 toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7

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and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 46 will be described below. FIG. **53**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 46. Moreover, FIG. **53**B, FIG. **53**C, FIG. **53**D, and FIG. **53**E are aberration diagrams of the optical system according to the example 46.

The optical system according to the example 46, as shown in FIG. 53A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens $L\mathbf{6}$ and the biconcave negative lens $L\mathbf{7}$.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 47 will be described below. FIG. **54**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 47. Moreover, FIG. **54**B, FIG. **54**C, FIG. **54**D, and FIG. **54**E are aberration diagrams of the optical system according to the example 47.

The optical system according to the example 47, as shown in FIG. **54**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a

biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 48 will be described below. FIG. 55A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 48. Moreover, FIG. 55B, 20 FIG. 55C, FIG. 55D, and FIG. 55E are aberration diagrams of the optical system according to the example 48.

The optical system according to the example 48, as shown in FIG. **55**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 25 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having 30 a convex surface directed toward an object side, and a negative meniscus lens L6 having a convex surface directed toward the object side. The positive meniscus lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the negative meniscus lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on the image side of the positive meniscus lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 49 will be 55 described below. FIG. **56**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 49. Moreover, FIG. **56**B, FIG. **56**C, FIG. **56**D, and FIG. **56**E are aberration diagrams of the optical system according to the example 49.

The optical system according to the example 49, as shown in FIG. **56**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens $L1_{65}$ having a convex surface directed toward an image side, a biconcave negative lens L2, a biconvex positive lens L3, a

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biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an object side, and a negative meniscus lens L6 having a convex surface directed toward the object side. The positive meniscus lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconcave negative lens L11, and a negative meniscus lens L12 having a convex surface directed toward the image side. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the negative meniscus lens L12.

The aperture stop S is disposed between the negative meniscus lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on the image side of the positive meniscus lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the negative meniscus lens L12

Next, an optical system according to an example 50 will be described below. FIG. 57A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 50. Moreover, FIG. 57B, FIG. 57C, FIG. 57D, and FIG. 57E are aberration diagrams of the optical system according to the example 50.

The optical system according to the example 50, as shown in FIG. 57A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 51 will be described below. FIG. **58**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 51. Moreover, FIG. **58**B, FIG. **58**C, FIG. **58**D, and FIG. **58**E are aberration diagrams of the optical system according to the example 51.

The optical system according to the example 51, as shown in FIG. 58A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1. 5 a biconcave negative lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave 20 negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of 25 the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 52 will be described below. FIG. 59A is a cross-sectional view along an 30 optical axis showing an optical arrangement of the optical system according to the example 52. Moreover, FIG. 59B, FIG. 59C, FIG. 59D, and FIG. 59E are aberration diagrams of the optical system according to the example 52.

The optical system according to the example 52, as shown 35 in FIG. 59A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a 40 a biconcave negative lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens 45 L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 50 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both 55 surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens 60 L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 53 will be described below. FIG. 60A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 53. Moreover, FIG. 60B, 65 FIG. 60C, FIG. 60D, and FIG. 60E are aberration diagrams of the optical system according to the example 53.

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The optical system according to the example 53, as shown in FIG. 60A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes a biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 54 will be described below. FIG. 61A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 54. Moreover, FIG. 61B, FIG. 6C, FIG. 61D, and FIG. 61E are aberration diagrams of the optical system according to the example 54.

The optical system according to the example 54, as shown in FIG. 61A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, positive meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 55 will be described below. FIG. **62**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 55. Moreover, FIG. 62B, FIG. 62C, FIG. 62D, and FIG. 62E are aberration diagrams of the optical system according to the example 55.

The optical system according to the example 55, as shown in FIG. **62**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 5 having a convex surface directed toward an object side, a biconvex positive lens L2, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are 10 cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconcave negative lens L9, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward an image side, and a biconcave negative lens L12. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 25 object side of the biconvex positive lens L2, a surface on the image side of the positive meniscus lens L3, a surface on the object side of the biconvex positive lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens 30 L11, an a surface on the image side of the biconcave negative lens L12.

Next, an optical system according to an example 56 will be described below. FIG. **63**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical 35 system according to the example 56. Moreover, FIG. **63**B, FIG. **63**C, FIG. **63**D, and FIG. **63**E are aberration diagrams of the optical system according to the example 56.

The optical system according to the example 56, as shown in FIG. **63**A, includes a first lens unit G1 having a positive 40 refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a diffractive optical element DL, a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward an object side, a 45 biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a 50 positive meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a negative meniscus lens L8 having a convex surface directed toward an image side, a biconvex positive lens L9, a biconcave negative 55 lens L10, and a biconcave negative lens L11. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive 60 power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward the object side and a negative meniscus lens having a convex surface directed toward the object side. A relief pattern is formed at an interface of the positive meniscus lens and 65 the negative meniscus lens, and the interface is let to be a diffractive surface.

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The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to 12 surfaces namely, a surface on the object side of the biconvex positive lens L1, a surface on the image side of the positive meniscus lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the negative meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 57 will be described below. FIG. **64A** is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 57. Moreover, FIG. **64B**, FIG. **64C**, FIG. **64D**, and FIG. **64E** are aberration diagrams of the optical system according to the example 57.

The optical system according to the example 57, as shown in FIG. **64**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a biconvex positive lens L2, a diffractive optical element DL, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconcave negative lens L9, and a negative meniscus lens L10 having a convex surface directed toward the object side. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L9 and the negative meniscus lens L10.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward the object side and a negative meniscus lens having a convex surface directed toward the object side. A relief pattern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to 11 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the biconvex positive lens L8, both surfaces of the biconcave negative lens L9, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 58 will be described below. FIG. **65**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 58. Moreover, FIG. **65**B, FIG. **65**C, FIG. **65**D, and FIG. **65**E are aberration diagrams of the optical system according to the example 58.

The optical system according to the example 58, as shown in FIG. 65A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive

meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a diffractive optical element DL, and a biconcave negative lens L11. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes a biconcave negative lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes a biconvex positive lens and a negative meniscus lens having 15 a convex surface directed toward an image side. A relief pattern is formed at an interface of the biconvex positive lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave 20 negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 10 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the positive meniscus lens L4, both surfaces of 25 the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 59 will be described below. FIG. **66**A is a cross-sectional view along an 30 optical axis showing an optical arrangement of the optical system according to the example 59. Moreover, FIG. **66**B, FIG. **66**C, FIG. **66**D, and FIG. **66**E are aberration diagrams of the optical system according to the example 59.

The optical system according to the example 59, as shown 35 in FIG. **66**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a 40 negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a diffractive optical element DL, a negative meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, and a biconcave negative lens L11. The biconcave negative 50 lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes 55 a positive meniscus lens having a convex surface directed toward the object side, and a negative meniscus lens having a convex surface directed toward the object side. A relief pattern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a 60 diffractive surface.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 65 object side of the biconvex positive lens L3, a surface on an image side of the biconvex positive lens L4, both surfaces of

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the diffractive optical element DL, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 60 will be described below. FIG. **67**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 60. Moreover, FIG. **67**B, FIG. **67**C, FIG. **67**D, and FIG. **67**E are aberration diagrams of the optical system according to the example 60.

The optical system according to the example 60, as shown in FIG. 67A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an object side, a biconvex positive lens L3, a diffractive optical element DL, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconcave negative lens L9, a biconvex positive lens L10, and a biconcave negative lens L11. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The diffractive optical element DL has a negative refractive power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward an object side and a negative meniscus lens having a convex surface directed toward the image side. A relief pattern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave negative lens $L\mathbf{5}$ and the negative meniscus lens $L\mathbf{6}$.

An aspheric surface is provided to 11 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 61 will be described below. FIG. **68**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 61. Moreover, FIG. **68**B, FIG. **68**C, FIG. **68**D, and FIG. **68**E are aberration diagrams of the optical system according to the example 61.

The optical system according to the example 61, as shown in FIG. **68**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a

negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 62 will be described below. FIG. **69**A is a cross-sectional view along an 20 optical axis showing an optical arrangement of the optical system according to the example 62. Moreover, FIG. **69**B, FIG. **69**C, FIG. **69**D, and FIG. **69**E are aberration diagrams of the optical system according to the example 62.

The optical system according to the example 62, as shown 25 in FIG. **69**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 30 biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a 40 negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative 45 meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the 50 biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative 55 meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 63 will be described below. FIG. **70**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical 60 system according to the example 63. Moreover, FIG. **70**B, FIG. **70**C, FIG. **70**D, and FIG. **70**E are aberration diagrams of the optical system according to the example 63.

The optical system according to the example 63, as shown in FIG. 70A, includes in order from an object side, a first lens 65 unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

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The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the image side, a negative meniscus lens L10 having a convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L10 and the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the negative meniscus lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 64 will be described below. FIG. 71A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 64. Moreover, FIG. 71B, FIG. 71C, FIG. 71D, and FIG. 71E are aberration diagrams of the optical system according to the example 64.

The optical system according to the example 64, as shown in FIG. 71A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the image side, a negative meniscus lens L10 having a convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L10 and the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the negative meniscus lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 65 will be described below. FIG. **72**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 65. Moreover, FIG. **72**B, FIG. **72**C, FIG. **72**D, and FIG. **72**E are aberration diagrams of the optical system according to the example 65.

The optical system according to the example 65, as shown in FIG. 72A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 5 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 20 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both 25 surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the 30 positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 66 will be described below. FIG. 73A is a cross-sectional view along an 35 negative lens L6 and the biconcave negative lens L7. optical axis showing an optical arrangement of the optical system according to the example 66. Moreover, FIG. 73B, FIG. 73C, FIG. 73D, and FIG. 73E are aberration diagrams of the optical system according to the example 66.

The optical system according to the example 66, as shown 40 in FIG. 73A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 45 biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a 55 negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative 60 meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the 65 biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens

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L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 67 will be described below. FIG. 74A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 67. Moreover, FIG. 74B, FIG. 74C, FIG. 74D, and FIG. 74E are aberration diagrams of the optical system according to the example 67.

The optical system according to the example 67, as shown in FIG. 74A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 68 will be described below. FIG. 75A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 68. Moreover, FIG. 75B, FIG. 75C, FIG. 75D, and FIG. 75E are aberration diagrams of the optical system according to the example 68.

The optical system according to the example 68, as shown in FIG. 75A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a biconcave negative lens L6, a biconvex positive lens L7, and a negative meniscus lens L8 having a convex surface directed toward an image side. The biconvex positive lens L7 and the negative meniscus lens L8 are cemented.

The second lens unit G2 includes a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the image side, a biconcave negative lens L11, a biconvex positive lens L12, a positive meniscus lens L13 having a convex surface directed toward the object side, a biconvex positive lens L14, a negative meniscus lens L15

having a convex surface directed toward the object side, a negative meniscus lens L16 having a convex surface directed toward the image side, and a biconcave negative lens L17. The positive meniscus lens L10, the biconcave negative lens L11, and the biconvex positive lens L12 are cemented. A 5 predetermined lens unit includes the negative meniscus lens L16 and the biconcave negative lens L17.

The aperture stop S is disposed between the negative meniscus lens L8 and the biconvex positive lens L9. More elaborately, the aperture stop is disposed between a vertex of an object-side surface of the biconvex positive lens L9 and a vertex of an image-side surface of the biconvex positive lens

An aspheric surface is provided to 24 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of 15 the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the biconvex positive lens L9, both surfaces of the positive menis- 20 L9, a positive meniscus lens L10 having a convex surface cus lens L13, both surfaces of the biconvex positive lens L14, both surfaces of the negative meniscus lens L15, both surfaces of the negative meniscus lens L16, and both surfaces of the biconcave negative lens L17.

Next, an optical system according to an example 69 will be 25 described below. FIG. 76A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 69. Moreover, FIG. 76B, FIG. 76C, FIG. 76D, and FIG. 76E are aberration diagrams of the optical system according to the example 69.

The optical system according to the example 69, as shown in FIG. 76A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens 35 L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a biconcave negative lens L6, a biconvex positive lens L7, and a biconcave negative lens L8. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented.

The second lens unit G2 includes a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward an image side, a biconcave negative lens L11, a biconvex positive lens L12, a positive meniscus lens L13 having a convex surface directed toward the object side, a 45 biconvex positive lens L14, a negative meniscus lens L15 having a convex surface directed toward the object side, a biconvex positive lens L16, and a biconcave negative lens L17. The positive meniscus lens L10, the biconcave negative lens L11, and the biconvex positive lens L12 are cemented. A 50 predetermined lens unit includes the biconcave negative lens L17.

The aperture stop S is disposed between the biconcave negative lens L8 and the biconvex positive lens L9. More elaborately, the aperture stop S is disposed between a vertex 55 L1, a biconvex positive lens L2, a biconvex positive lens L3, of an object-side surface of the biconvex positive lens L9 and a vertex of an image-side surface of the biconvex positive lens L9.

An aspheric surface is provided to 24 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of 60 the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L13, both surfaces of the biconvex positive lens L14, both surfaces of the negative meniscus lens L15, both sur106

faces of the biconvex positive lens L16, and both surfaces of the biconcave negative lens L17.

Next, an optical system according to an example 70 will be described below. FIG. 77A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 70. Moreover, FIG. 77B, FIG. 77C, FIG. 77D, and FIG. 77E are aberration diagrams of the optical system according to the example 70.

The optical system according to the example 70, as shown in FIG. 77A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a biconcave negative lens L6, a biconvex positive lens L7, and a biconcave negative lens L8. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented.

The second lens unit G2 includes a biconvex positive lens directed toward an image side, a biconcave negative lens L11, a biconvex positive lens L12, a positive meniscus lens L13 having a convex surface directed toward the object side, a biconvex positive lens L14, a negative meniscus lens L15 having a convex surface directed toward the object side, and a negative meniscus lens L16 having a convex surface directed toward the image side. The positive meniscus lens L10, the biconcave negative lens L11, and the biconvex positive lens L12 are cemented. A predetermined lens unit includes the negative meniscus lens L15 and the negative meniscus lens L16.

The aperture stop S is disposed between the biconcave negative lens L8 and the biconvex positive lens L9.

An aspheric surface is provided to 22 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L13, both surfaces of the biconvex positive lens L14, both surfaces of the negative meniscus lens L15, and both surfaces of the negative meniscus lens L16.

Next, an optical system according to an example 71 will be described below. FIG. 78A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 71. Moreover, FIG. 78B, FIG. 78C, FIG. 78D, and FIG. 78E are aberration diagrams of the optical system according to the example 71.

The optical system according to the example 71, as shown in FIG. 78A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens a biconvex positive lens L4, a biconcave negative lens L5, a biconvex positive lens L6, and a biconcave negative lens L7. The biconvex positive lens L $\mathbf{6}$ and the biconcave negative lens L7 are cemented.

The second lens unit G2 includes a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward an image side, a biconcave negative lens L10, a biconvex positive lens L11, a positive meniscus lens L12 having a convex surface directed toward the object side, a biconvex positive lens L13, a negative meniscus lens L14 having a convex surface directed toward the object side, and a negative meniscus lens L15 having a convex surface

directed toward the image side. The positive meniscus lens L9, the biconcave negative lens L10, and the biconvex positive lens L11 are cemented. A predetermined lens unit includes the negative meniscus lens L14 and the negative meniscus lens L15.

The aperture stop S is disposed between the biconcave negative lens L7 and the biconvex positive lens L8. More elaborately, the aperture stop S is disposed between a vertex of an object-side surface of the biconvex positive lens L8 and a vertex of an image-side surface of the biconvex positive lens 10 L8.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconcave negative lens L5, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L12, both surfaces of the biconvex positive lens L13, both surfaces of the negative meniscus lens L14, and both surfaces of the negative meniscus lens L15.

Next, an optical system according to an example 72 will be described below. FIG. **79**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 72. Moreover, FIG. **79**B, FIG. **79**C, FIG. **79**D, and FIG. **79**E are aberration diagrams of 25 the optical system according to the example 72.

The optical system according to the example 72, as shown in FIG. 79A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. 30

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The 35 positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a negative meniscus lens L9 having a convex surface directed 40 toward the image side, a positive meniscus lens L10 having a convex surface directed toward the image side, a biconvex positive lens L11, and a negative meniscus lens L12 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are 45 cemented. A predetermined lens unit includes the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 16 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 73 will be described below. FIG. **80**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical 60 system according to the example 73. Moreover, FIG. **80**B, FIG. **80**C, FIG. **80**D, and FIG. **80**E are aberration diagrams of the optical system according to the example 73.

The optical system according to the example 73, as shown in FIG. **80**A, includes in order from an object side, a first lens 65 unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

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The first lens unit G1 includes a biconcave negative lens L1, a positive meniscus lens L2 having a convex surface directed toward an image side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a negative meniscus lens L6 having a convex surface directed toward the image side, a positive meniscus lens L7 having a convex surface directed toward the image side, a biconcave negative lens L8, a biconvex positive lens L9, and a negative meniscus lens L10 having a convex surface directed toward the image side. The biconvex positive lens L9 and the negative meniscus lens L10 are cemented.

The second lens unit G2 includes a positive meniscus lens L11 having a convex surface directed toward the object side, a biconvex positive lens L12, a biconcave negative lens L13, a biconvex positive lens L14, a positive meniscus lens L15 having a convex surface directed toward the object side, a biconvex positive lens L16, a negative meniscus lens L17 having a convex surface directed toward the object side, a positive meniscus lens L18 having a convex surface directed toward the image side, and a biconcave negative lens L19. The biconvex positive lens L12, the biconcave negative lens L13, and the biconvex positive lens L14 are cemented. A predetermined lens unit includes the biconcave negative lens L19.

The aperture stop S is disposed between the negative meniscus lens L10 and the positive meniscus lens L11.

An aspheric surface is provided to 28 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of the positive meniscus lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the negative meniscus lens L6, both surfaces of the positive meniscus lens L7, both surfaces of the biconcave negative lens L8, both surfaces of the positive meniscus lens L11, both surfaces of the positive meniscus lens L15, both surfaces of the biconvex positive lens L16, both surfaces of the negative meniscus lens L17, both surfaces of the positive meniscus lens L18, and both surfaces of the biconcave negative lens L19.

Next, an optical system according to an example 74 will be described below. FIG. **81**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 74. Moreover, FIG. **81**B, FIG. **81**C, FIG. **81**D, and FIG. **81**E are aberration diagrams of the optical system according to the example 74.

The optical system according to the example 74, as shown in FIG. 81A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the image side, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconvex positive lens L10, a biconcave negative lens L11, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative 5 meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 75 will be described below. FIG. **82**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 75. Moreover, FIG. **82**B, 15 FIG. **82**C, FIG. **82**D, and FIG. **82**E are aberration diagrams of the optical system according to the example 75.

The optical system according to the example 75, as shown in FIG. 82A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 20 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed 25 toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, 30 a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, a negative meniscus lens L12 having a convex surface directed toward the image side, and a biconcave negative lens L13. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 18 surfaces namely, both 40 surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the 45 biconvex positive lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 76 will be described below. FIG. **83**A is a cross-sectional view along an 50 optical axis showing an optical arrangement of the optical system according to the example 76. Moreover, FIG. **83**B, FIG. **83**C, FIG. **83**D, and FIG. **83**E are aberration diagrams of the optical system according to the example 76.

The optical system according to the example 76, as shown 55 in FIG. 83A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 60 biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9,

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a biconvex positive lens L10, a biconcave negative lens L11, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 77 will be described below. FIG. **84**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 77. Moreover, FIG. **84**B, FIG. **84**C, FIG. **84**D, and FIG. **84**E are aberration diagrams of the optical system according to the example 77.

The optical system according to the example 77, as shown in FIG. 84A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward the image side, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 78 will be described below. FIG. **85**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 78. Moreover, FIG. **85**B, FIG. **85**C, FIG. **85**D, and FIG. **85**E are aberration diagrams of the optical system according to the example 78.

The optical system according to the example 78, as shown in FIG. **85**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the image side, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, 10 a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward the image side, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 79 will be 30 described below. FIG. **86**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 79. Moreover, FIG. **86**B, FIG. **86**C, FIG. **86**D, and FIG. **86**E are aberration diagrams of the optical system according to the example 79.

The optical system according to the example 79, as shown in FIG. **86**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, 40 a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens 50 L13 having a convex surface directed toward the image side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, an object-side surface of the biconvex positive lens L3, an image-side surface of 60 the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, an both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 80 will be described below. FIG. 87A is a cross-sectional view along an

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optical axis showing an optical arrangement of the optical system according to the example 80. Moreover, FIG. 87B, FIG. 87C, FIG. 87D, and FIG. 87E are aberration diagrams of the optical system according to the example 80.

The optical system according to the example 80, as shown in FIG. 87A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconcave negative lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a positive meniscus lens L11 having a convex surface directed toward the object side, a positive meniscus lens L11 having a convex surface directed toward the object side, a piconcave negative lens L12, and a biconcave negative lens L13. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 10 surfaces namely, an image-side surface of the negative meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, an object-side surface of the positive meniscus lens L11, and an image-side surface of the biconcave negative lens L13.

Next, an optical system according to an example 81 will be described below. FIG. **88**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 81. Moreover, FIG. **88**B, FIG. **88**C, FIG. **88**D, and FIG. **88**E are aberration diagrams of the optical system according to the example 81.

The optical system according to the example 81, as shown in FIG. 88A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a negative meniscus lens L11 having a convex surface directed toward the object side, a positive meniscus lens L12 having a convex surface directed toward the object side, and a biconcave negative lens L13. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 12 surfaces namely, an image-side surface of the negative meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive menis-

cus lens L10, both surfaces of the negative meniscus lens L11, an object-side surface of the positive meniscus lens L12, and an image-side surface of the biconcave negative lens L13.

Next, an optical system according to an example 82 will be described below. FIG. **89**A is a cross-sectional view along an 5 optical axis showing an optical arrangement of the optical system according to the example 82. Moreover, FIG. **89**B, FIG. **89**C, FIG. **89**D, and FIG. **89**E are aberration diagrams of the optical system according to the example 82.

The optical system according to the example 82, as shown 10 in FIG. 89A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 15 biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconcave negative lens L10, a positive meniscus lens L11 having a convex surface directed toward the object side, and a biconcave negative lens L12. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 10 surfaces namely, an image-side surface of the negative meniscus lens 11, an 30 object-side lens of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, an object-side surface of the positive meniscus lens L11, and an image-side surface of the bicon-35 cave negative lens L12.

Next, an optical system according to an example 83 will be described below. FIG. **90A** is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 83. Moreover, FIG. **90B**, 40 L5. FIG. **90C**, FIG. **90D**, and FIG. **90E** are aberration diagrams of the optical system according to the example 83.

The optical system according to the example 83, as shown in FIG. 90A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 45 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a 50 biconvex positive lens L6, and a biconcave negative lens L7. The biconvex positive lens L6 and the biconcave negative lens L7 are cemented.

The second lens unit G2 includes a biconcave negative lens L8, a biconvex positive lens L9, a biconvex positive lens L10, 55 a biconvex positive lens L11, a negative meniscus lens L12 having a convex surface directed toward the image side, a biconvex positive lens L13, a negative meniscus lens L14 having a convex surface directed toward the image side, and a biconcave negative lens L15. The biconcave negative lens L8 and the biconvex positive lens L9 are cemented. A predetermined lens unit includes the negative meniscus lens L14 and the biconcave negative lens L15.

The aperture stop S is disposed between the biconcave negative lens L7 and the biconcave negative lens L8.

An aspheric surface is provided to 22 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the

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biconvex positive lens L2, both surfaces of the biconcave negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the negative meniscus lens L12, both surfaces of the biconvex positive lens L13, both surfaces of the negative meniscus lens L14, and both surfaces of the biconcave negative lens L15.

Next, an optical system according to an example 84 will be described below. FIG. 91A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 84. Moreover, FIG. 91B, FIG. 91C, FIG. 91D, and FIG. 91E are aberration diagrams of the optical system according to the example 84.

The optical system according to the example 84, as shown in FIG. 91A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an image side, a positive meniscus lens L3 having a convex surface directed toward the image side, and a negative meniscus lens L4 having a convex surface directed toward the object side. The biconvex positive lens L1 and the negative meniscus lens L2 are cemented.

The second lens unit G2 includes a biconvex positive lens L5, a biconcave negative lens L6, a negative meniscus lens L7 having a convex surface directed toward the image side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the image side, and a negative meniscus lens L10 having a convex surface directed toward the object side. A predetermined lens unit includes the negative meniscus lens L10.

The aperture stop S is disposed between the negative meniscus lens L4 and the biconvex positive lens L5. More elaborately, the aperture stop S is disposed between a vertex of an object-side surface of the biconvex positive lens L5 and a vertex of an image-side surface of the biconvex positive lens L5.

An aspheric surface is provided to 16 surfaces namely, both surface of the positive meniscus lens L3, both surfaces of the negative meniscus lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the negative meniscus lens L7, both surfaces of the positive meniscus lens L8, both surfaces of the positive meniscus lens L9, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 85 will be described below. FIG. 92A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 85. Moreover, FIG. 92B, FIG. 92C, FIG. 92D, and FIG. 92E are aberration diagrams of the optical system according to the example 85.

The optical system according to the example 85, as shown in FIG. 92A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconcave negative lens L9, a biconvex positive lens L10,

and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave 5 negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, 10 both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 86 will be described below. FIG. 93A is a cross-sectional view along an 15 optical axis showing an optical arrangement of the optical system according to the example 86. Moreover, FIG. 93B, FIG. 93C, FIG. 93D, and FIG. 93E are aberration diagrams of the optical system according to the example 86.

The optical system according to the example 86, as shown 20 in FIG. 93A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 25 biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconcave negative lens L9, a biconvex positive lens L10, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both 40 surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the 45 negative meniscus lens L11.

Next, an optical system according to an example 87 will be described below. FIG. **94**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 87. Moreover, FIG. **94**B, 50 FIG. **94**C, FIG. **94**D, and FIG. **94**E are aberration diagrams of the optical system according to the example 87.

The optical system according to the example 87, as shown in FIG. 94A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 55 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed 60 toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, 65 a negative meniscus lens L9 having a convex surface directed toward the image side, a positive meniscus lens L10 having a

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convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the positive meniscus lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 88 will be described below. FIG. 95A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 88. Moreover, FIG. 95B, FIG. 95C, FIG. 95D, and FIG. 95E are aberration diagrams of the optical system according to the example 88.

The optical system according to the example 88, as shown in FIG. 95A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a biconvex positive lens L7, a biconvex positive lens L8, a negative meniscus lens L9 having a convex surface directed toward the image side, a positive meniscus lens L10 having a convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The negative meniscus lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6. More elaborately, the aperture stop is disposed between a vertex of an object-side surface of the biconcave negative lens L5 and a vertex of an image-side surface of the biconcave negative lens L5.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens $\rm L1$, both surfaces of the biconvex positive lens $\rm L2$, both surfaces of the biconvex positive lens $\rm L3$, both surfaces of the biconvex positive lens $\rm L8$, both surfaces of the negative meniscus lens $\rm L9$, both surfaces of the positive meniscus lens $\rm L10$, and both surfaces of the negative meniscus lens $\rm L11$.

Next, an optical system according to an example 89 will be described below. FIG. **96**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 89. Moreover, FIG. **96**B, FIG. **96**C, FIG. **96**D, and FIG. **96**E are aberration diagrams of the optical system according to the example 89.

The optical system according to the example 89, as shown in FIG. 96A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a

positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens 5 L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, and a negative meniscus lens L12 10 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave 15 negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 16 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3. both surfaces of the biconvex positive lens L8. 20 both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 90 will be 25 described below. FIG. 97A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 90. Moreover, FIG. 97B, FIG. 97C, FIG. 97D, and FIG. 97E are aberration diagrams of the optical system according to the example 90.

The optical system according to the example 90, as shown in FIG. 97A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens 35 L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The biconcave negative lens L1 and the biconvex positive lens L2 are cemented. Moreover, 40 the biconvex positive lens L4, the positive meniscus lens L5, and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a 45 biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the 50 negative lens L6 and the negative meniscus lens L7. biconcave negative lens L12 and the positive meniscus lens

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

No aspheric surface is used.

Next, an optical system according to an example 91 will be described below. FIG. 98A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 91. Moreover, FIG. 98B, FIG. 98C, FIG. 98D, and FIG. 98E are aberration diagrams of 60 the optical system according to the example 91.

The optical system according to the example 91, as shown in FIG. 98A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. 65

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3,

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a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The biconcave negative lens L1 and the biconvex positive lens L2 are cemented. Moreover, the biconvex positive lens L4, the positive meniscus lens L5, and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the positive meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

No aspheric surface is used.

Next, an optical system according to an example 92 will be described below. FIG. 99A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 92. Moreover, FIG. 99B, FIG. 99C, FIG. 99D, and FIG. 99E are aberration diagrams of the optical system according to the example 92.

The optical system according to the example 92, as shown in FIG. 99A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a positive meniscus lens L2 having a convex surface directed toward the image side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave negative lens L6. The negative meniscus lens L1 and the positive meniscus lens L2 are cemented. Moreover, the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, and a negative meniscus lens L12 having a convex surface directed toward the object side. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave

No aspheric surface is used.

Next, an optical system according to an example 93 will be described below. FIG. 100A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 93. Moreover, FIG. 100B, FIG. 100C, FIG. 100D, and FIG. 100E are aberration diagrams of the optical system according to the example 93.

The optical system according to the example 93, as shown in FIG. 100A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The biconcave negative lens L1 and the biconvex positive lens L2 are cemented. Moreover,

the biconvex positive lens L4, the positive meniscus lens L5, and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a 5 biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the 10 biconcave negative lens L12 and the positive meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

No aspheric surface is used.

Next, an optical system according to an example 94 will be described below. FIG. 101A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 94. Moreover, FIG. 101B, grams of the optical system according to the example 94.

The optical system according to the example 94, as shown in FIG. 101A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. 25

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a positive meniscus lens L2 having a convex surface directed toward the image side, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex 30 positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, 35 a biconcave negative lens L9, a biconvex positive lens L10, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11, 40

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

No aspheric surface is used.

Next, an optical system according to an example 95 will be described below. FIG. 102A is a cross-sectional view along 45 an optical axis showing an optical arrangement of the optical system according to the example 95. Moreover, FIG. 102B, FIG. 102C, FIG. 102D, and FIG. 102E are aberration diagrams of the optical system according to the example 95.

The optical system according to the example 95, as shown 50 in FIG. 102A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a 55 biconvex positive lens L2, a diffractive optical element DL, a biconvex positive lens L3, and a negative meniscus lens L4 having a convex surface directed toward the image side. The biconvex positive lens L3 and the negative meniscus lens L4 are cemented.

The second lens unit G2 includes a biconcave negative lens L5, a biconvex positive lens L6, a biconvex positive lens L7, a negative meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward 65 the object side, and a biconcave negative lens L11. The biconcave negative lens L5 and the biconvex positive lens L6 are

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cemented. A predetermined lens unit includes the negative meniscus lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a negative refractive power as a whole. The diffractive optical element DL includes a negative meniscus lens having a convex surface directed toward the image side and a biconcave negative lens. A relief pattern is formed at an interface of the negative meniscus lens and the biconcave negative lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the negative meniscus lens L4 and the biconcave negative lens L5.

An aspheric surface is provided to eight surfaces namely, an image-side surface of the positive meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L7, both surfaces of the negative meniscus lens L8, an object-side surface of the biconvex positive lens L9, and an image-side surface of the biconcave negative lens L11.

Next, an optical system according to an example 96 will be FIG. 101C, FIG. 101D, and FIG. 101E are aberration dia- 20 described below. FIG. 103A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 96. Moreover, FIG. 103B, FIG. 103C, FIG. 103D, and FIG. 103E are aberration diagrams of the optical system according to the example 96.

> The optical system according to the example 96, as shown in FIG. 103A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

> The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a positive meniscus lens L3 having a convex surface directed toward the image side, a diffractive optical element DL, a biconvex positive lens L4, and a negative meniscus lens L5 having a convex surface directed toward the image side. The biconvex positive lens L4 and the negative meniscus lens L5 are cemented.

> The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a negative meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconcave negative lens L11, and a negative meniscus lens L12 having a convex surface directed toward the image side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the negative meniscus lens L12.

> The diffractive optical element DL has a negative refractive power as a whole. The diffractive optical element DL includes a negative meniscus lens having a convex surface directed toward the image side and a biconcave negative lens. A relief pattern is formed at an interface of the negative meniscus lens and the biconcave negative lens, and the interface is let to be a diffractive surface.

> The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

> An aspheric surface is provided to eight surfaces namely, an image-side surface of the positive meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L8, both surfaces of the negative meniscus lens L9, an object-side surface of the biconvex positive lens L10, and an image-side surface of the negative meniscus lens L12.

> Next, numerical data of optical components comprising the image pickup optical system of each above example are shown. In numerical data of each example, r1, r2, ... denotes a curvature radius of each lens surface, d1, d2, . . . denotes a thickness of each lens or an air distance between adjacent lens surfaces, nd1, nd2, ... denotes a refractive index of each lens

-continued Unit mm

for d-line, v1, vd2, . . . denotes an Abbe number of each lens, * denotes an aspheric surface, focal length denotes a focal length of an overall optical system, fb denotes a back focus, NA denotes a numerical aperture on the object side. NA' denotes a numerical aperture on an image side. The lens 5 total length is the distance from the frontmost lens surface to the rearmost lens surface plus back focus. Further, back focus is a unit which is expressed upon air conversion of a distance from the lens backmost surface to a paraxial image surface.

A shape of an aspheric surface is defined by the following expression where the direction of the optical axis is represented by z, the direction orthogonal to the optical axis is represented by y, a conical coefficient is represented by K, aspheric surface coefficients are represented by A4, A6, A8, 15 A10, A12, A14,

$$Z = (y^2/r)/[1 + \left\{1 - (1 + k)(y/r)^2\right\}^{1/2}J + A4y^4 + A6y^6 + A8y^8 + A10y^{10} + A12y^{12} + A14y^{14}\right\}$$

Further, E or e stands for exponent of ten. These symbols 20 are commonly used in the following numerical data for each example.

Example 1

	Unit r	nm		
	Surface	data		
Surface no.	r	d	nd	νd
Object plane	∞	10.00		
1*	56.907	2.99	1.53368	55.9
2*	-4.184	0.89		
3*	5.571	2.08	1.63490	23.8
4*	2.582	1.78		
5*	-12.567	1.55	1.53368	55.9
6*	-9.471	0.16		
7*	-81.714	1.53	1.61417	25.6
8*	16.993	1.27		
9*	10.146	0.89	1.53368	55.9
10*	2551.254	0.05		
11(Stop)	∞	0.05		
12*	-2551.254	0.89	1.53368	55.9
13*	-10.146	1.27		
14*	-16.993	1.53	1.61417	25.6
15*	81.714	0.16		
16*	9.471	1.55	1.53368	55.9
17*	12.567	1.78		
18*	-2.582	2.08	1.63490	23.8
19*	-5.571	0.89		
20*	4.184	2.99	1.53368	55.90
21*	-56.907	10.00		
Image plane	œ			

Aspherical surface data

l st	surface	

k = -971.414

A4 = 5.02632E-004, A6 = -1.89989E-005, A8 = 7.41491E-0082nd surface

A4 = -1.17216E - 004, A6 = -3.40925E - 006, A8 = -7.12080E - 0083rd surface

A4 = -3.68418E - 004, A6 = 1.23021E - 006, A8 = -1.91476E - 0074th surface

A4 = -5.11751E - 005, A6 = 2.59016E - 005, A8 = -4.23106E - 006

5th surface k = -41.834A4 = 1.16926E-003, A6 = 4.04202E-005, A8 = 5.90751E-007 6th surface

k = -10.826

A4 = 1.20017E - 003, A6 = -1.67324E - 004, A8 = 1.00681E - 0057th surface

k = -323.372A4 = -1.33721E-003, A6 = -7.57104E-005

k = -56.057A4 = 5.62466E-004, A6 = 2.31800E-005 9th surface

A4 = -4.31572E-004, A6 = 7.85879E-006 10th surface

k = -3367.122A4 = -1.08162E - 00312th surface

k = -3367.122A4 = 1.08162E - 00313th surface

k = -8.574

A4 = 4.31572E-004, A6 = -7.85879E-00630

14th surface

k = -56.057A4 = -5.62466E - 004, A6 = -2.31800E - 00515th surface

k = -323.372A4 = 1.33721E-003, A6 = 7.57104E-00516th surface

k = -10.826

 ${\rm A4} = -1.20017{\rm E} - 003, {\rm A6} = 1.67324{\rm E} - 004, {\rm A8} = -1.00681{\rm E} - 005$ 17th surface

k = -41.834

A4 = -1.16926E - 003, A6 = -4.04202E - 005, A8 = -5.90751E - 00718th surface

A4 = 5.11751E-005, A6 = -2.59016E-005, A8 = 4.23106E-00619th surface

k = -0.820

A4 = 3.68418E - 004, A6 = -1.23021E - 006, A8 = 1.91476E - 00720th surface

k = -3.546

A4 = 1.17216E - 004, A6 = 3.40925E - 006, A8 = 7.12080E - 00821th surface

k = -971.414

A4 = -5.02632E - 004, A6 = 1.89989E - 005, A8 = -7.41491E - 008

	Various dat	a	
60	Focal length	103.95	
	Image height	3.00	
	Object height	3.00	
	fb(in air)	10.00	
	Lens total length(in air)	36.40	
	NA	0.25	
65	NA'	0.25	

continued

	Unit n	nm		
	Surface	data		
Surface no.	r	d	nd	νd
Object plane	œ	10.00		
1* 2*	56.907	2.99	1.53368	55.90
2** 3*	-4.184 5.571	0.89 2.08	1.63490	23.88
4*	2.582	1.78	1.05450	25.00
5*	-12.567	1.55	1.53368	55.90
6*	-9.471	0.16		
7*	-81.714	1.53	1.61417	25.64
8*	16.993	1.27		
9*	10.146	0.89	1.53368	55.90
10* 11(Stop)	2551.254 ∞	0.05 0.05		
11(Stop) 12*	-2755.354	0.88	1.53368	55.90
13*	-10.197	1.27	1.55500	55.50
14*	-17.162	1.52	1.61417	25.64
15*	80.905	0.16		
16*	9.945	1.51	1.53368	55.90
17*	13.196	1.78		22 -
18*	-2.579	2.10	1.63490	23.88
19*	-5.515 4.205	0.89	1 52260	55.00
20* 21*	4.205 -52.429	3.01 9.95	1.53368	55.90
Image plane	−32.429 ∞	1.13		
J 1	Aspherical su	irface data		
st surface	Asphericar su	irrace data		
= -3.546 44 = -1.17216E-004, rd surface = -0.820 44 = -3.68418E-004, th surface = -2.549 44 = -5.11751E-005, th surface = -41.834 44 = 1.16926E-003, A th surface	A6 = 1.23021E-(A6 = 2.59016E-(006, A8 = -1 005, A8 = -4	.91476E-007	
x = -10.826 A4 = 1.20017E-003, A th surface	A6 = -1.67324E-0	004, A8 = 1.0	00681E-005	
x = -323.372 A4 = -1.33721E-003, ath surface	A6 = -7.57104E-	-005		
x = -56.057 A4 = 5.62466E-004, A Oth surface	A6 = 2.31800E-00)5		
x = -8.574 A4 = -4.31572E-004, Oth surface	A6 = 7.85879E-0	006		
x = -3367.122 A4 = -1.08162E-003 2th surface				
t = -1.000 $t = 1.01390E - 003$				

	-continued	
	Unit mm	
5	13th surface	
_	k = -34.706 A4 = 1.53163E-004, A6 = -3.32586E-005 14th surface	
10	k = -115.470 A4 = -3.35747E-004, A6 = -6.40043E-005, A 15th surface	8 = -2.43136E-006
	k = -3938.246 A4 = 3.76944E-004, A6 = 7.29277E-005, A8 = 16th surface	-4.82792E-007
15	$k = -8.155 \\ A4 = -1.45390E-003, A6 = 1.19689E-004, A8 \\ \underline{17} th \ surface$	= -4.23958E-006
20	k = -54.092 A4 = -1.43817E-003, A6 = -4.56510E-005, A 18th surface	8 = -9.34587E-007
	$\begin{array}{l} k = -2.544 \\ A4 = -2.21738E - 004, A6 = -1.23369E - 005, A19th surface \end{array}$	8 = 1.78875E-006
25	$\begin{array}{l} k = -0.962 \\ A4 = 5.90516E - 004, A6 = -9.40093E - 007, A8 \\ 20th surface \end{array}$	= 2.83619E-007
30	k = -3.386 A4 = -5.94157E-004, $A6 = -2.05054E-005$, $A621th surface$	8 = -1.51161E-007
	k = -997.069 A4 = -1.39558E-003, A6 = 3.03292E-008, A8	= -2.09782E-007
35	Various data	
,,	Focal length Image height Object height fb(in air) Lens total length(in air)	117.54 3.00 3.04 9.95 36.31
1 0	NA NA'	0.25 0.25

Example 3

	Ţ	Jnit mm		
	Su	rface data		
Surface no.	r	d	nd	νd
Object plane	œ	10.00		
1*	24.287	3.82	1.53368	55.90
2*	-8.002	0.24		
3*	-41.811	1.65	1.53368	55.90
4*	-5.934	0.10		
5*	5.062	1.71	1.63490	23.88
6*	2.521	2.46		
7*	-5.494	1.55	1.53368	55.90
8*	-8.447	0.84		
9*	-19.714	1.55	1.61417	25.64
10*	62.109	0.30		
11*	8.611	1.45	1.53368	55.90
12*	83.241	0.10		
13(Stop)	∞	0.10		
14*	-83.241	1.45	1.53368	55.90
15*	-8.611	0.30		
16*	-62.109	1.55	1.61417	25.64
17*	19.714	0.84		
18*	8,447	1.55	1.53368	55.90

tinued	-continu

-continued		-continued				
Unit mm		Unit mm				
19* 5.494 2.46	– 5	18th surface				
20* -2.521 1.71 1.63490 23.88 21* -5.062 0.10 22* 5.934 1.65 1.53368 55.90 23* 41.811 0.24 24* 8.002 3.82 1.53368 55.90 25* -24.287 10.00	J	k = -29.993 A4 = -2.31315E 19th surface k = -13.090	8-003, A6 = 2.671	.74E-004	, A8 = -8.203	78E-006
Image plane Aspherical surface data	1 0		E-003, A6 = 9.948	891E-005	, A8 = -3.387	74E-006
1st surface	_	k = -2.293 A4 = 1.77915E- 21th surface	-003			
k = -38.162 A4 = 2.16640E-004, A6 = -1.95771E-005 2nd surface	15	k = -2.669 A4 = 6.29227E- 22th surface	-004			
k = 0.297 A4 = 1.77235E-004 3rd surface	20	k = -8.215 $A4 = -3.34614E$ 23th surface	3-004, A6 = 1.450)43E-005		
k = 51.696 A4 = -7.96667E-005 4th surface	_	k = 51.696 A4 = 7.96667E- 24th surface	-005			
k = -8.215 A4 = 3.34614E-004, A6 = -1.45043E-005 5th surface	25	k = 0.297 A4 = -1.77235E 25th surface	E-004			
k = -2.669 A4 = -6.29227E-004 6th surface	— 30 –	k = -38.162 $A4 = -2.16640$	E-004, A6 = 1.957	771E-005		
k = -2.293	50 -		Variou	ıs data		
A4 = -1.77915E-003 7th surface k = -13.090 A4 = 2.91976E-003, A6 = -9.94891E-005, A8 = 3.38774E-006 8th surface	35	Lens total length (in air) 41.51 NA 0.25		0 0 0 1 5		
k = -29.993 A4 = 2.31315E-003, A6 = -2.67174E-004, A8 = 8.20378E-006 9th surface	40	NA'	Exam	ıple 4	0.2	5
k = -144.855 A4 = -1.30120E-003, A6 = -1.92446E-004 10th surface						
k = -112.335 A4 = -4.38857E-004, A6 = 7.19917E-005	45 -		Unit Surfac			
11th surface		Surface no.	r	d	nd	vd
k = -11.820 A4 = -1.83703E-003, A6 = 5.10296E-005 12th surface	50	Object plane 1* 2*	∞ 118.590 −4.253	10.00 3.22 1.22	1.53368	55.90
k = -992.499 A4 = -2.26937E-003 14th surface		3* 4* 5* 6*	5.650 2.592 -12.289	2.03 2.12 1.26	1.63490 1.53368	23.88 55.90
k = -992.499 A4 = 2.26937E-003 15th surface	55	7* 8* 9* 10*	-10.692 2017.727 18.173 9.307 -1637.972	0.42 0.75 0.91 1.21 0.05	1.61417 1.53368	25.64 55.90
k = -11.820 A4 = 1.83703E-003, A6 = -5.10296E-005 16th surface	60	11(Stop) 12* 13* 14*	∞ 1637.972 −9.307 −18.173	0.05 1.21 0.91 0.75	1.53368 1.61417	55.90 25.64
k = -112.335 A4 = 4.38857E-004, A6 = -7.19917E-005 17th surface		15* 16* 17* 18*	-2017.727 10.692 12.289 -2.552	0.42 1.26 2.12 1.28	1.53368 1.63490	55.90 23.88
k = -144.855 A4 = 1.30120E-003, A6 = 1.92446E-004	65	19* 20* 21* 22*	-4.995 -8.574 -10.336 4.253	0.20 1.73 0.27 3.22	1.61417 1.53368	25.64 55.90
•		23*	-118.590	10.00	1.33308	J J.7 U

14/		
-continued		

	_			mueu		
Unit mm	_		Unit	mm		
Image plane ∞	5	20th surface				
Aspherical surface data		k = -5.877 A4 = 7.79125E-1	004 461 32	507E_005		
1st surface	_	21th surface	004, A0 = -1.32.	707E-003		
k = -8136.470 A4 = 5.71134E-004, A6 = -2.00614E-005 2nd surface	10	k = -1.068 A4 = 5.79930E- 22th surface	004, A6 = 8.8642	27E-007		
k = -3.272 A4 = 9.59493E-005, A6 = -1.26826E-005 3rd surface		k = -3.272 A4 = -9.59493E 23th surface	-005, A 6 = 1.268	326E-005		
k = -1.068 A4 = -5.23801E-004 4th surface	15	k = -8136.470 A4 = -5.71134E-004, A6 = 2.00614E-005				
k = -2.482	_		Variou	ıs data		
A4 = -8.74470E-004 5th surface	20	Focal len			60.48	
k = -40.369 A4 = 1.42420E-004, A6 = -3.86408E-005, A8 = 7.11239E-006 6th surface	_	Image height 3.00 Object height 3.00 fb (in air) 10.00 Lens total length (in air) 36.64				
k = -10.478 A4 = 1.17511E-003, A6 = -2.78573E-004, A8 = 1.44945E-005 7th surface	25	NA NA'			0.25 0.25	
k = -29.482 A4 = -1.47024E-003, A6 = -9.25880E-005 8th surface	30		Exam	iple 5		
k = -73.068 A4 = 2.28159E-004, A6 = 2.12332E-005 9th surface		Unit mm				
k = -8.721	35		Surfac	e data		
A4 = -3.04856E-004, A6 = 1.03002E-005 10th surface	33	Surface no.	r	d	nd	νd
k = -9998.897 A4 = -9.87805E-004 12th surface	_	Object plane 1* 2*	∞ 156.483 −4.185	10.00 2.97 0.64	1.53368	55.90
k = -9998.897	— 40	3* 4*	5.631 2.482	2.24 2.06	1.63490	22.53
A4 = 9.87805E - 004		5* 6*	-12.289 -10.692	1.26 0.30	1.53368	55.90
13th surface	_	7*	749.711	0.75	1.61417	26.36
k = -8.721	45	8* 9*	20.875 9.307	0.91 1.21	1.53368	55.90
A4 = 3.04856E-004, A6 = -1.03002E-005 14th surface		10*	-1637.972	0.05		
		11(Stop) 12*	∞ 1637.972	0.05 1.21	1.53368	55.90
k = -73.068 A4 = -2.28159E-004, A6 = -2.12332E-005		13* 14*	-9.307 -16.779	0.36 1.62	1 61 41 7	29.34
15th surface	50	15*	-10.779 -107.079	0.10	1.61417	29.34
	_	16*	10.692	1.26	1.53368	55.90
k = -29.482 A4 = 1.47024E-003, A6 = 9.25880E-005		17* 18*	12.289 -6.330	2.12 2.13	1.63490	23.88
16th surface		19*	-4.032	0.20		
1 10 470	_	20* 21*	-3.868 11.399	1.91 1.30	1.58366	31.95
k = -10.478 A4 = -1.17511E-003, A6 = 2.78573E-004, A8 = -1.44945E-005	55	22*	4.898	4.02	1.53368	55.90
17th surface	_	23* Image plane	−20.043 ∞	18.15		
k = -40.369			Aspherical:	surface de	ta	
A4 = -1.42420E-004, A6 = 3.86408E-005, A8 = -7.11239E-006 18th surface	60	Lat gurfage	Asplicited	sarrace da		
	_	1st surface				
k = -2.482		k = -9921.522 A4 = 5.99647E-004	A6 = -2.35081E	-005, A 8 :	= -3.20796E-	007
A4 = 8.47704E-004, A6 = -1.73683E-005 19th surface	_	2nd surface				
	— 65					

	- 1
-continu	ed

Unit mm	_		Unit 1	mm		
3rd surface		23th surface				
k = -1.357 A4 = -7.07427E-004, A6 = 1.47946E-006, A8 = 1.15313E-007 4th surface		k = -1.000				
k = -2.659 A4 = -7.98462E-004, A6 = -2.43747E-005, A8 = 5.79988E-007 5th surface	A4 = -4.00926E-004, A6 = -3.90604E-006, A8 = -5.44114E-00)8
			Various	s data		
k = -40.369 A4 = 1.42420E-004, A6 = -3.86408E-005, A8 = 7.11239E-006 6th surface		Focal len Image he	~		26.53 5.00	
x = -10.478 A4 = 1.17511E-003, A6 = -2.78573E-004, A8 = 1.44945E-005 7th surface	15	Object he fb (in air)	eight		2.99 18.15	
x = -2.268 A4 = -1.14080E-004, $A6 = -1.24060E-004$, $A8 = -2.30974E-0068th surface$	20	Lens tota NA NA'	l length (in air)		46.84 0.25 0.15	
x = -31.531 A4 = 4.20068E-004, A6 = 7.16535E-005, A8 = -5.41984E-006 Oth surface						
x = -8.721 A4 = -3.04856E-004, A6 = 1.03002E-005 l0th surface	25		Exam	ple 6		
x = -9998.897 A4 = -9.87805E-004		Unit mm				
2th surface	30		Surface	data		
= -9998.897 44 = 9.87805E-004		Surface no. Object plane	r	d 1.21	nd	νd
3th surface		1*	-0.784	0.48	1.53071	55.78
= -8.721 44 = 3.04856E-004, A6 = -1.03002E-005 4th surface	35	2* 3* 4*	-130.797 0.642 2.354	0.05 0.59 0.49	1.53071	55.78
:= -70.427 A4 = 1.69673E-004, A6 = -2.70114E-005, A8 = 1.08912E-007 5th surface	40	5* 6* 7* 8*	-2.684 17.387 2.980 -1.789	0.29 0.04 0.70 -0.11	1.63490 1.53071	23.88 55.78
x = -9997.910 A4 = 1.71452E-003, A6 = 1.19083E-004, A8 = -3.69775E-006 .6th surface		9(Stop) 10* 11* 12*	∞ 1.410 -25.302 -63.214	0.21 0.54 0.05 0.30	1.53463 1.63490	56.22 23.88
		13* 14*	2.768 -2.355	0.71 0.65	1.53463	56.22
:= -10.478 A4 = -1.17511E-003, A6 = 2.78573E-004, A8 = -1.44945E-005	45	15*	-0.912	0.13		
7th surface = -40.369		16* 17* Image plane	-251.493 1.312 ∞	0.59 1.46	1.53463	56.22
A4 = -1.42420E-004, A6 = 3.86408E-005, A8 = -7.11239E-006			Aspherical s	urface data		
8th surface	50	1st surface				
x = -2.482 A4 = 4.04572E-004, A6 = -8.29704E-005 9th surface		k = -7.734 A4 = 1.18541E-001,				
x = -1.068 A4 = 2.63204E-003, A6 = -1.24324E-004 20th surface	55	A10 = -7.67536E-00 2nd surface k = 0.000				
x = -2.596 A4 = 3.85952E-003, A6 = -1.23399E-004		A4 = 8.48095E-002, A10 = 6.37573E-003 3rd surface				
21th surface x = -50.829 A4 = 9.71515E-004, A6 = -1.03384E-005 22th surface	60	$k = -3.546 \\ A4 = 2.70583E-001, A6 = -2.54490E-001, A8 = 1.89589E-001, \\ A10 = -1.87543E-001, A12 = 5.94237E-002 \\ 4th surface$				
x = -5.617 A4 = -9.26264E-005, A6 = -1.51831E-005, A8 = 2.25669E-007	65	k = -1.947 A4 = 9.60228E-002, A10 = -5.89337E-00			2.47936E-003	3,

132

131 -continued				13 Exam			
Unit mm		_					
5th surface		— 5		Unit	mm		
k = -24.611				Surface	data		
A4 = -1.29167E-001, A6 = 1.92617E-001, A A10 = -9.41339E-002, A12 = -7.64900E-00 6th surface	· · · · · · · · · · · · · · · · · · ·		Surface no.	r	d	nd	νd
k = 0.000 A4 = 7.10538E-002, A6 = 3.04047E-001, A8 A10 = -1.67999E-001, A12 = 5.47114E-001 7th surface		10	Object plane 1* 2* 3* 4* 5*	∞ -1.312 251.493 0.912 2.355 -2.768	1.46 0.59 0.13 0.65 0.71 0.30	1.53463 1.53463 1.63490	56.22 56.22 23.88
k = -4.762 A4 = 9.68323E-002, A6 = 3.65189E-001, A8 A10 = 7.47746E-002, A12 = 6.35189E-001 8th surface	3 = -8.02417E-001,	15	6* 7* 8* 9(Stop) 10*	63.214 25.302 -1.410 ∞ 1.789	0.05 0.54 0.21 -0.11 0.70	1.53463 1.53071	56.22
k = -0.571 A4 = 4.95207E-002, A6 = -1.12153E-001, A A10 = -1.28927E+000, A12 = 1.11371E+000 10th surface	· · · · · · · · · · · · · · · · · · ·	20	11* 12* 13* 14* 15*	-2.980 -17.387 2.684 -2.354 -0.642	0.04 0.29 0.49 0.59 0.05	1.63490 1.53071	23.88 55.78
k = 0.062 A4 = 1.37414E-002, A6 = -5.71487E-002, A A10 = 4.18364E-001, A12 = -4.83502E-001 11th surface		25	16* 17* Image plane	130.797 0.784 ∞ Aspherical s	0.48 1.21 urface data	1.53071	55.78
k = 0.000 A4 = 1.42573E-001, A6 = -6.53135E-001, A A10 = 2.63676E+000, A12 = -3.61580E+000 A16 = 4.40252E-001 12th surface	· · · · · · · · · · · · · · · · · · ·	30	1st surface $k = -9.247$				
k = -495.266 A4 = 1.85957E-001, A6 = -8.01875E-001, A A10 = 2.01491E+000, A12 = -2.75814E+000 13th surface	,	35	2nd surface k = -420.200 A4 = 4.70698F-002, A6 = 1.74511F-002, A8 = -1.68346F-002				
k = -4.665 A4 = 1.82826E-001, A6 = -3.29495E-001, A A10 = -1.56281E-001, A12 = -1.45670E-00 14th surface		— 40	3rd surface k = -4.154 A4 = 2.53695E-001, A6 = -3.45811E-001, A8 = 3.37286E-001, A10 = -1.58499E-001, A12 = 2.70778E-002				
k = -1.122 A4 = -5.90880E-002, A6 = 1.80998E-001, A A10 = 3.48644E-001, A12 = -1.35538E-001 15th surface	· · · · · · · · · · · · · · · · · · ·		4th surface k = -1.122 A4 = 5.90880E-002, A10 = -3.48644E-00 5th surface			20905E-001,	
k = -4.154 A4 = -2.53695E-001, A6 = 3.45811E-001, A A10 = 1.58499E-001, A12 = -2.70778E-002 16th surface	· · · · · · · · · · · · · · · · · · ·	45	k = -4.665 A4 = -1.82826E-001 A10 = 1.56281E-001, 6th surface		,	5.73943E-00	ι,
k = -420.200 A4 = -4.70698E-002, A6 = -1.74511E-002, A10 = -4.41443E-003, A12 = 5.27904E-004		50	k = -495.266 A4 = -1.85957E-001 A10 = -2.01491E+000 7th surface			7.78375E-003	1,
k = -9.247 A4 = -7.76409E-002, A6 = 2.54240E-002, A A10 = 1.79672E-003, A12 = -2.29048E-004 Various data		55	k = 0.000 A4 = -1.42573E-001 A10 = -2.63676E+000 A16 = -4.40252E-00 8th surface	0, A12 = 3.61580	/		/
Focal length Image height Object height fb (in air) Lens total length (in air)	1.52 2.85 2.24 1.46 7.16	60	k = 0.062 A4 = -1.37414E-002 A10 = -4.18364E-00 10th surface			66765E–002,	
NA NA'	0.22 0.17	65	k = -0.571 A4 = -4.95207E-002 A10 = 1.28927E+000		,	7.03902E-003	ι,

65 A4 = -4.95207E-002, A6 = 1.12153E-001, A8 = -7.03902E-001, A10 = 1.28927E+000, A12 = -1.11371E+000

-continued -continued

Unit mm			Unit mm	
11th surface		_ 5 :	Image plane ∞	
x = -4.762 A4 = -9.68323E-002, A6 = -3.65189E-001, A	A8 = 8.02417E-001,	•	Aspherical surface data	
A10 = -7.47746E-002, A12 = -6.35189E-001 12th surface		`	4th surface	
k = 0.000 A4 = -7.10538E-002, A6 = -3.04047E-001, A10 = 1.67999E-001, A12 = -5.47114E-001 13th surface	A8 = 7.45538E-001,	10	k = 0.000 A4 = 7.06954e-05 12th surface	
x = -24.611 A4 = 1.29167E-001, A6 = -1.92617E-001, A8 A10 = 9.41339E-002, A12 = 7.64900E-002 14th surface	8 = 6.67246E-002,	15	k = -0.579 A4 = 3.23636e-08 13th surface k = 0.000	
k = -1.947 A4 = -9.60228E-002, A6 = 2.78077E-002, A8 A10 = 5.89337E-002, A12 = -1.60644E-001 15th surface	8 = 2.47936E-003,	20	A4 = 1.99801e-05 14th surface k = 0.000 A4 = -5.42705e-04	
k = -3.546 A4 = -2.70583E-001, A6 = 2.54490E-001, A6 A10 = 1.87543E-001, A12 = -5.94237E-002 16th surface	8 = -1.89589E-001,		15th surface k = 0.000 A4 = -1.29917e-05	
k = 0.000 A4 = -8.48095E-002, A6 = 1.72116E-002, Ai A10 = -6.37573E-003, A12 = 8.49967E-004, 17th surface k = -7.734 A4 = -1.18541E-001, A6 = 5.85984E-002, Ai	A14 = 3.53042E-006	30	16th surface k = 0.000 A4 = 4.43608e-04 17th surface k = 0.000	
A10 = 7.67536E-003, A12 = -1.18366E-003, Various data	A14 = 7.33016E-005		A4 = -7.74339e-04, A6 = -4.9670 Various data	5e-06
Focal length	1.52	 .		0.15
Image height Object height fb (in air) Lens total length (in air) NA	2.24 2.85 1.21 6.91 0.17	33	NA Magnification Focal length Image height (mm) fb (mm) (in air)	0.15 -1.04 9.34 4.92 4.21
NA'	0.22	40	Lens total length (mm) (in air)	34.92

Example 8

Example 9

						45						
		Unit mm				_						
	5	Surface dat	ta			_			Unit mm			
						-		S	urface da	ta		
Surface no.	r	d	nd	vd	θgf	50	Surface no.	r	d	nd	νd	θgf
1	20.000	3.16	1.49700	81.61	0.538	_						
2	-29.914	1.23					1	24.757	4.50	1.49700	81.61	0.538
3	12.304	3.27	1.49700	81.61	0.538		2	-20.382	0.14			
4*	133.906	0.19					3*	-83.898	1.15	1.53368	55.90	0.563
5	9.781	3.54	1.61800	63.33	0.544	55	4*	28.935	0.15			
6	-30.296	0.98	1.72047	34.71	0.583	00	5	14.657	4.68	1.49700	81.61	0.538
7	6.120	1.14					6*	-22.520	2.49			
8(Stop)	∞	0.73					7	8.244	3.90	1.61800	63.33	0.544
9	-13.763	0.70	1.90366	31.32	0.595		8	-18.524	0.70	1.72047	34.71	0.583
10	-552.475	1.65	1.61800	63.33	0.544		9	6.509	1.16			
11	-30.000	0.10				60	10(Stop)	∞	1.00			
12*	7.964	2.99	1.49700	81.61	0.538	60	11	-7.654	1.06	1.90366	31.32	0.595
13*	29.995	1.94					12	-19.862	2.42	1.61800	63.33	0.544
14*	105.854	2.67	1.58364	30.30	0.599		13	-14.476	0.10			
15*	-9.793	5.72					14*	10.185	4.10	1.49700	81.61	0.538
16*	-5.613	0.70	1.53368	55.90	0.563		15*	-13.446	0.10			
17*	4970.723	3.70					16*	22.889	3.01	1.58364	30.30	0.599
18	œ	0.30	1.51640	65.06	0.535	65	17*	-29.222	5.24			
19	∞	0.31					18*	-6.641	0.70	1.53368	55.90	0.563

15

_ 20

25

30

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45

50

55

60

65

133	
. 1	
-continued	

	Commue	a.			_	
	Unit mm					
16.877 ∞ ∞	3.70 0.30 0.31	1.51640	65.06	0.535	5	-

Aspherical surface data

3rd surface	
s = 0.000	

A4 = -5.08296e - 05, A6 = -5.46138e - 074th surface

A4 = 1.91756e-05, A6 = -4.56532e-076th surface

 $\mathbf{k} = 0.000$ A4 = 4.28078e - 0514th surface

19*

20 21 Image plane

> k = -0.579A4 = -5.62366e - 0715th surface

k = 0.000A4 = 1.84420e-04 16th surface

k = 0.000A4 = -4.33240e - 0517th surface

k = 0.000A4 = 1.44611e-04 18th surface

k = 0.000 A4 = 2.83534e-04 19th surface

k = 0.000 A4 = -7.46747e-04, A6 = 4.74306e-06

Various data	
NA	0.21
Magnification	-1.05
Focal length	9.35
Image height (mm)	4.92
fb (mm) (in air)	4.21
Lens total length (mm) (in air)	40.82

Example 10

		Unit mm			
	S	urface dat	a		
Surface no.	r	d	nd	\mathbf{v} d	$\theta g f$
1	20.000	3.29	1.49700	81.61	0.538
2	-27.197	0.40			
3	12.782	3.47	1.49700	81.61	0.538
4*	186.607	0.99			
5	10.290	3.50	1.61800	63.33	0.544
6	-17.388	0.86	1.72047	34.71	0.583
7	6.090	1.02			
8(Stop)	∞	0.75			
9	-12.294	0.70	1.90366	31.32	0.595
10	-69.652	1.69	1.61800	63.33	0.544
11	-20.000	0.10			
12	8.145	3.21	1.49700	81.61	0.538

-continued

		Unit mm			
13	-15.000	0.95	1.51742	52.43	0.556
14	11.934	0.72			
15*	12.723	2.63	1.58364	30.30	0.599
16*	-12.612	5.70			
17*	-5.132	0.73	1.53368	55.90	0.563
18*	-59.830	3.70			
19	00	0.30	1.51640	65.06	0.535
20	∞	0.31			
Image plane	∞				

Aspherical surface data

k = 0.000	
A4 = 9.03821e-05	
15th surface	
k = 0.000	
A4 = -1.16458e - 04	
16th surface	

k = 0.000A4 = 4.25245e - 0418th surface

k = 0.000A4 = -8.51966e-04, A6 = -6.89946e-06

Various data					
NA	0.15				
Magnification	-1.03				
Focal length	9.35				
Image height (mm)	4.92				
fb (mm) (in air)	4.21				
Lens total length (mm) (in air)	34.91				

Example 11

Unit mm

	S	urface dat	ta		
Surface no.	r	d	nd	vd	θ
1	15.000	3.56	1.49700	81.61	0.53
2	-34.400	0.10			
3	11.283	3.07	1.49700	81.61	0.53
4*	114.633	1.10			
5	11.882	3.29	1.61800	63.33	0.54
6	-23.894	1.08	1.72047	34.71	0.53
7	6.254	0.98			
8(Stop)	œ	0.41			
9	28.157	0.70	1.90366	31.32	0.5
10	12.525	1.62	1.61800	63.33	0.5
11	29.622	4.65			
12*	19.060	2.87	1.49700	81.61	0.5
13*	-20.715	0.10			
14	30.351	3.69	1.86400	40.58	0.5
15	-8.760	0.84	1.56384	60.67	0.54
16	33.363	1.93			
17*	-8.111	0.70	1.53368	55.90	0.5
18*	20.135	3.70			
19	∞	0.30	1.51640	65.06	0.5
20	œ	0.31			
Image plane	œ				

137	130
continued	-continued

-continued						_			-contin	ued			
	Unit mm								Unit n	ım			
	Asp	herical su	rface data			- 5	Aspherical surface data						
	4th surface					-		2nd surface					
	k = 0.000					_		k = -4.214 3rd surface					
	A4 = 1.82154e- 12th surface	-04				10	k = 0.000 A4 = 3.91871e-05, A6 = 3.19948e-08 4th surface						
	k = -0.579 A4 = -2.537430 13th surface	e-05				— 15	k = 0.000 A4 = -2.66544e-04, A6 = 4.29908e-08						
	k = 0.000 A4 = 1.30619e- 17th surface	-04				_		k = -1.434 $A4 = -1.944396$ 16 th surface	e−04				
	k = 0.000 A4 = 2.60653e-04 18th surface							k = -0.579 A4 = 2.99389e-04 17th surface					
k = 0.000 A4 = -2.39609e-04, A6 = 9.46048e-07						25	k = 0.000 A4 = -1.11526e-04 18th surface						
Various data						_		k = 2.656 A4 = -2.507906 19th surface	e-04				
NA 0.15 Magnification -1.03 Focal length 10.22						30	$\begin{array}{c} k = 0.000 \\ 30 & A4 = 1.33117e{-04} \\ \underline{20th \ surface} \end{array}$						
f	Image height (mm) 4.92 fb (mm) (in air) 4.21 Lens total length (mm) (in air) 34.91				25	k = 0.000 A4 = 2.61407e-04 21th surface							
						- 35							
		Exampl	le 12					data					
		TT '4				4 0	NA 0.18 Magnification -1.05 Focal length 7.99						
		Unit m Surface				-		Image height (mm fb (mm) (in air)	,		4.92 2.77		
					O- f	- 45		Lens total length (mm) (in a	ır)	34.88		
Surface no. 1	96.073	2.73	nd 1.84666	vd 23.77	θgf 0.620	-			Exampl	e 13			
2* 3*	-18.251 -23.375	0.30 0.50	1.58364	30.30	0.599				r.				
4* 5*	10.401 9.515	0.30 3.87	1.49700	81.61	0.538	50							
6 7	-32.363 10.328	0.10 3.78	1.49700	81.61	0.538				Unit m	ım			
8 9	-34.714 10.969	0.30 2.74	1.61800	63.33	0.544				Surface	data			
10	-26.411	0.61	1.72047	34.71	0.583		Surface no.	r	d	nd	vd	$\theta g f$	
11 12(Stop)	5.686 ∞	1.34 0.30				55	1	47.665	2.51	1.84666	23.77	0.620	
13	15.413	0.50	1.72047	34.71	0.583		2*	-21.643	0.30				
14 15	9.057 9.689	1.61 1.83	1.61800	63.33	0.544		3* 4*	-78.703 8.889	0.50 0.30	1.58364	30.30	0.599	
16*	9.565	2.26	1.49700	81.61	0.538		5*	8.817	3.03	1.49700	81.61	0.538	
17* 18*	340.758 11.503	1.70 2.38	1.63490	23.88	0.630	60	6 7	-86.120 9.186	0.10 3.18	1.49700	81.61	0.538	
19*	1563.756	3.01					8	-23.055	0.30				
20* 21*	-5.590 57.014	1.96 2.21	1.53368	55.90	0.563		9 10	12.987 -22.422	2.57 0.87	1.61800 1.72047	63.33 34.71	0.544 0.583	
22	∞	0.38	1.51640	65.06	0.535		11	5.211	0.94	1.72047	J-1./1	0.565	
23 Image plane	& &	0.30				65	12(Stop) 13	∞ 19.357	0.30 1.64	1.61800	63.33	0.544	
mage plane	~					_	13	-39.123	0.50	1.72047	34.71	0.583	

0.538

0.630

0.563

0.535

Unit mm

3.60

2.21

2.42

2.64

2.45

0.75

2.20

0.38

0.31

2nd surface k = -3.077 3rd surface k = 0.000 A4 = -3.60571e-05 4th surface k = 0.000 A4 = -1.12816e-04 5th surface

 $k = -0.996 \\ A4 = -7.73645e-05 \\ \underline{16th \ surface} \\ k = -0.579 \\ A4 = 7.09702e-04 \\ \underline{17th \ surface} \\$

k = 0.000 A4 = 5.12138e-04 18th surface

k = -0.174 A4 = -2.01937e-0619th surface

k = 0.000A4 = -3.03025e-07 20th surface

k = 0.000 A4 = 1.53947e-06 21th surface k = 0.000 A4 = -1.55823e-06Various data

Magnification

Focal length

Image height (mm)

Lens total length (mm) (in air)

fb (mm) (in air)

Aspherical surface data

11.556

11.244

8.310

32.497

-8.166

18.771

8

 ∞

5498.309

15

16* 17* 18*

19*

20* 21* 22 23

Image plane

1.49700

1.63490

1.53368

1.51640

81.61

23.88

55.90

65.06

		-(continue	ed		
			Unit mm			
5	4* 5* 6	8.363 8.022 -27.821	0.45 4.21 0.10	1.49700	81.61	0.538
	7	12.314	3.81	1.49700	81.61	0.538
10	8 9 10 11	-15.006 15.820 -16.606 5.917	0.30 2.48 0.86 1.11	1.61800 1.72047	63.33 34.71	0.544 0.583
	12(Stop) 13 14	∞ 19.831 8.704	0.30 1.50 3.25	1.59542	57.26	0.547
15	15* 16* 17*	30.113 -129.450 11.178	2.20 1.44 3.22	1.49700 1.63490	81.61 23.88	0.538
	18* 19*	69.854 -11.756	2.52 1.72	1.53368	55.90	0.563
	20* 21	28.321 ∞	2.45 0.38	1.51640	65.06	0.535
20	22 Image plane	8	0.30			
		Asphe	rical surfa	ce data		
25		2nd st	ırface			
20		k = -6 3rd su				
30		k = 0. A4 = - 4th su	-1.06326e	:-04		
		k = 0. A4 = - 5th su	-4.80995e	:-04		
35			297 -2.89846e urface	:-04		
40).579 -2.76313e urface	:-06		
15			000 4.96403e- urface	-06		
45			161 -1.96685e urface	:-05		
50			000 9.87207e- urface	-06		
55			000 8.51271e- urface	-06		
•		k = 0. A4 =	000 -2.32962e	:-05		
60		V	⁄arious dat	a		
60	Foc	gnification al length age height (mm)			0.14 -1.05 9.49 4.92	

fb (mm) (in air)

Lens total length (mm) (in air)

65

3.00

35.87

Example 1

0.13

-1.05

8.59

4.92

2.76

33.88

		Unit mm			
	1	Surface dat	ta		
Surface no.	r	d	nd	νd	$\theta g f$
1 2*	47.850 -22.343	2.59 0.30	1.84666	23.77	0.620
3*	-42.136	0.50	1.58364	30.30	0.599

142 -continued

								Unit mm				
Unit mm						- 5		21th surface				
Surface data						-	k = 0.000 A4 = -2.39642e-04, A6 = -9.62165e-07					
Surface no.	r	d	nd	\mathbf{v} d	θgf	_			Various	data		
1* 2*	17.425 26.052	1.99 2.15	1.84666	23.77	0.620	10		NA			0.21	
3	78.603	2.65	1.49700	81.61	0.538		N	Magnification Focal length			-1.05 8.84	
4 5	-23.793 20.854	0.10 2.93	1.49700	81.61	0.538			mage height (mm)		4.92	
6*	-28.805	0.97						b (mm) (in air)	> ('		3.21	
7 8	10.233 -14.403	3.22 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583	15		Lens total length (шш) (ш а	ir <i>)</i>	43.94	
9	6.263	1.54										
10(Stop)	∞	2.59	4.002.66	24.22	0.505							
11	-23.449	1.10	1.90366	31.32	0.595				Examp1	e 16		
12 13	23.820 -13.224	4.50 0.10	1.61800	63.33	0.544	20			1			
14*	20.191	4.92	1.49700	81.61	0.538	20						
15*	-12.021	2.06										
16*	16.842	2.97	1.58364	30.30	0.599				Unit m	m		
17*	-61.090	2.44	1.40700	01 (1	0.529							
18* 19*	-13.902 22.930	0.70 2.41	1.49700	81.61	0.538	25			Surface	data		
20*	-7.006	0.70	1.53368	55.90	0.563		Surface no.	r	d	nd	νd	$\theta g f$
21*	42.359	2.70					1 18	44.00	2.00	1.04655	22.77	0.000
22	∞	0.30	1.51640	65.06	0.535		1* 2*	44.490 1042.481	2.90 0.10	1.84666	23.77	0.620
23 Image plane	& &	0.31				3.0	3	32.397 -23.206	3.52	1.49700	81.61	0.538
	Aspheri	cal surfa	ce data			- 30	4 5	14.648	0.10 3.55	1.49700	81.61	0.538
						-	6* 7	-33.420 11.152	0.10 3.61	1.61800	63.33	0.544
1st sı	urface					_	8	-8.805	0.70	1.72047	34.71	0.583
k = 0	0.000						9 10(Stop)	5.456 ∞	0.96 0.72			
A4 =	= 1.14998e-04					35	10(Stop)	-9.368	0.72	1.90366	31.32	0.595
2nd s	surface					_	12	58.101	4.03	1.61800	63.33	0.544
k = 0	000						13 14*	-11.863 22.578	1.16 4.50	1.49700	81.61	0.538
	= 1.87722e-04						15*	-10.017	1.59	1.49700	01.01	0.556
	urface					_ 40	16*	33.644	3.89	1.58364	30.30	0.599
						_ +0	17*	-23.118	5.88	1.52269	55.00	0.563
k = 0	0.000 = 7.02747e-05						18* 19*	-8.960 13.998	0.70 3.70	1.53368	55.90	0.563
	= 7.027476-03 surface						20	∞	0.30	1.51640	65.06	0.535
1111	barrage					_	21	∞	0.31			
	-0.579 = –8.56059e–05	:				45	Image plane	∞				
/14 =	surface	,				_		Asp	herical su	rface data		
15th												
k = 0	0.000							1st surface				
k = 0 A4 =).000 = -4.50576e-05	5						k = 0.000	0.5			
k = 0 A4 =	0.000	5				_ 50			.05			
k = 0 A4 = 16th k = 0	0.000 = -4.50576e-05 surface	5				_ 50		k = 0.000 A4 = 9.48776e- 2nd surface	05			
k = 0 A4 = 16th k = 0 A4 =	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05	5				_ 50		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000				
k = 0 A4 = 16th k = 0 A4 =	0.000 = -4.50576e-05 surface	;				_ ⁵⁰		k = 0.000 A4 = 9.48776e- 2nd surface				
k = 0 A4 = 16th k = 0 A4 =	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface	5				- ⁵⁰		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.316366 6th surface				
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 =	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface 0.000 = 3.13794e-05	5				_		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.31636e 6th surface k = 0.000	-04			
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 =	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface	5				_		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.316366 6th surface	-04			
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface 0.000 = 3.13794e-05 surface	5				_		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.31636e 6th surface k = 0.000 A4 = 4.63529e- 14th surface	-04			
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 =	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface 0.000 = 3.13794e-05 surface	5				_		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.316366 6th surface k = 0.000 A4 = 4.63529e- 14th surface k = -0.579 A4 = -8.095116	-04			
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19th	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface 0.000 = 3.13794e-05 surface 0.000 = 3.45712e-04 surface	,				- 55		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.31636e 6th surface k = 0.000 A4 = 4.63529e- 14th surface k = -0.579 A4 = -8.09511e 15th surface	-04			
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19th k = 0	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface 0.000 = 3.13794e-05 surface 0.000 = 3.45712e-04 surface					- 55		k = 0.000 A4 = 9.48776e-2nd surface k = 0.000 5A4 = 1.31636e 6th surface k = 0.000 A4 = 4.63529e-14th surface k = -0.579 A4 = -8.09511e 15th surface k = 0.000	04 05 05			
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19th k = 0 A4 =	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface 0.000 = 3.13794e-05 surface 0.000 = 3.45712e-04 surface					- 55		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.31636e 6th surface k = 0.000 A4 = 4.63529e- 14th surface k = -0.579 A4 = -8.09511e 15th surface	04 05 05			
k = 0 A4 = 16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19th k = 0 A4 =	0.000 = -4.50576e-05 surface 0.000 = 6.70751e-05 surface 0.000 = 3.13794e-05 surface 0.000 = 3.45712e-04 surface 0.000 = 3.45712e-04 surface					- 55		k = 0.000 A4 = 9.48776e- 2nd surface k = 0.000 5A4 = 1.31636e 6th surface k = 0.000 A4 = 4.63529e- 14th surface k = -0.579 A4 = -8.09511e 15th surface k = 0.000 A4 = 1.88059e-	04 05 05			

-continued			-continued				
Unit mm			Unit mm				
17th surface		<u> </u>	16th surface				
k = 0.000 A4 = -1.26355e-05 18th surface			k = 0.000 A4 = 1.82606e-04 17th surface k = 0.000 A4 = -4.51042e-04, A6 = -1.53697e-06				
k = 0.000 A4 = 2.75080e-04 19th surface		10					
k = 0.000			Various data				
A4 = -4.02076e - 04, $A6 = 6.67549$	e-07		NA NA	0.20			
Various data		15	Magnification Focal length	-1.05 10.21			
NA Magnification Focal length	0.18 -1.05 10.48		Image height (mm) fb (mm) (in air) Lens total length (mm) (in air)	4.92 4.21 40.13			
Image height (mm) fb (mm) (in air) Lens total length (mm) (in air)	4.92 4.21 42.91	20	Example 18				
Example 17			Ziminpie 10				
1		25	Unit mm				

						25	25 Unit mm							
						_		S	urface da	ta				
		Unit n				_	Surface n	o. r	d	nd	νd	$\theta \mathrm{gf}$		
		Surface	data			- ₃₀ -	1	20.000	3.41	1.49700	81.61	0.538		
Surface no.	r	d	nd	νd	θ gf	30	2	-21.403	0.10	1.49700	81.01	0.558		
						_	3	10.837	2.84	1.49700	81.61	0.538		
1	30.001	3.55	1.49700	81.61	0.538		4*	419.463	0.10					
2	-20.144	0.10					5	29.618	2.52	1.61800	63.33	0.544		
3	14.839	2.95	1.49700	81.61	0.538		6	-14.040	0.70	1.72047	34.71	0.583		
4*	-204.753	1.38				35	7	9.509	3.36					
5	9.541	3.61	1.61800	63.33	0.544		8(Stop)	∞	0.20					
6	-22.503	0.94	1.72047	34.71	0.583		9	15.000	0.70	1.59551	39.24	0.580		
7	5.977	1.25					10	4.665	2.31	1.64769	33.79	0.594		
8(Stop)	∞	1.09					11	14.569	0.75					
9	-7.570	1.76	1.90366	31.32	0.595		12*	18.814	2.92	1.49700	81.61	0.538		
10	-16.099	2.78	1.61800	63.33	0.544	40	13*	-8.306	0.10					
11	-10.217	0.10				40	14	-27.184	4.50	1.86400	40.58	0.567		
12*	11.695	5.99	1.49700	81.61	0.538		15	-13.984	0.80					
13*	-15.540	1.31					16	-10.364	2.42	1.56384	60.67	0.540		
14*	26.431	2.57	1.58364	30.30	0.599		17	42.568	2.09					
15*	405.879	5.84					18*	-4.588	0.88	1.53368	55.90	0.563		
16*	-6.493	0.70	1.53368	55.90	0.563		19*	-17.205	3.70					
17*	676.071	3.70				45	20	∞	0.30	1.51640	65.06	0.535		
18	∞	0.30	1.51640	65.06	0.535		21	∞	0.31					
19	∞	0.31					Image pla	ine ∞						
Image plane	∞							Asphe	rical surfa	ice data				
	Asp	herical su	rface data			-			Tour burn					
	4th surface					- 50		4th surface						
						_		k = 0.000						
	k = 0.000							A4 = 1.96955e - 04						
	A4 = 5.71106e- 12th surface	-05						12th surface						
						 55		k = -0.579						
	k = -0.579					33		A4 = 1.16008e-04						
	A4 = 1.53768e	-05						13th surface						
	13th surface					_		1- 0.000						
	k = 0.000							k = 0.000 A4 = 6.10145e-04						
	A4 = 6.02131e	0.5							+					
	14th surface	-03				60		18th surface						
	1- 0.000				_	_		k = 0.000						
	k = 0.000 $A4 = -8.638266$	- 05						A4 = 5.15864e - 04	+					
	A4 = -8.038206 15th surface	2-03						19th surface						
								k = 0.000						
	k = 0.000					65		A4 = -8.95475e - 0	94, A6 = -	-1.08381e-05	5			
	A4 = -5.743336	e-05				-								

		-conti	nued					-0	continue	ed		
		Unit r	nm			-			Unit mm			
						. 5	19th	surface				
	NT A	Various	data	0.15		•	A4 =).000 = 5.26452e-05				
	NA Magnification			0.15 -1.04			20th	surface				
	Focal length			8.63		10		0.000				
	Image height (mr	n)		4.92		10		= 3.84196e-05 surface				
	fb (mm) (in air)	/		4.21								
	Lens total length	(mm) (in	air)	34.91).000 = 6.16533e–05				
		. , ,						surface				
						15	k = (0.000				
		Examp	ام 10					= 1.47300e-04 surface				
		Ехапр	19									
						20	A4 =).000 = -6.49627e-0 surface	5			
		Unit r	nm				k = (0.000				
		Surface	data			_	A4 =	= -5.07397e-0	5			
Surface no.	r	d	nd	vd	$\theta g f$		<u>25th</u>	surface				
1	15.792	2.15	1.60999	27.48	0.620	. 25).000 = -5.85345e-0	A & 6 1	304762 06		
2	23.978	0.00	1001.00000	-3.45	0.296	_	A4 =	= -3.633436-0	4, A0 = 1	.304706-00		
3	23.978	0.20	1.63762	34.21	0.594			V	⁄arious da	ta		
4 5*	23.780 14.045	2.78 4.50	1.49700	81.61	0.538	-	NA				0.15	
6	-93.714	0.10	1.15700	01.01	0.550	30	Magnit	ication			-1.00	
7	12.954	2.81	1.49700	81.61	0.538		Focal l	ength			9.02	
8* 9	48.862 27.146	0.93 2.74	1.61800	63.33	0.544			height (mm) ı) (in air)			4.92 1.75	
10	-13.584	0.73	1.72047	34.71	0.583			otal length (mn	n) (in air)		42.28	
11	18.090	1.34				-			-, (,			
12(Stop) 13	∞ 13.257	0.02 0.72	1.90366	31.32	0.595	35						
14	5.010	1.34	1.61800	63.33	0.544			Ex	ample	20		
15	8.118	0.75						L.	icinipi c			
16* 17*	6.148 10.525	2.11 2.08	1.49700	81.61	0.538							
18*	-7.323	3.11	1.49700	81.61	0.538	40 -						
19*	-7.585	0.91				40			Unit mm			
20* 21*	14.481 -16.233	3.56 1.90	1.58364	30.30	0.599	-			urface da			
22*	-12.939	0.71	1.49700	81.61	0.538	-		ა	urrace da	.a		
23*	41.071	4.34					Surface no.	r	d	nd	νd	θgf
24*	-7.245	0.70	1.53368	55.90	0.563	45	1 %	22.024	2.51	1 94666	22.77	0.620
25* 26	54812.275 ∞	0.38	1.51640	65.06	0.535		1* 2*	32.834 -14.478	2.51 0.74	1.84666	23.77	0.620
27	∞	0.29					3*	-13.008	0.70	1.58364	30.30	0.599
Image plane	∞					_	4* 5*	10.024 6.167	0.11 4.69	1.49700	81.61	0.538
	As	pherical si	ırface data			-	6*	-9.896	0.16	1.49/UU	01.01	0.558
						- 50	7	14.247	2.75	1.61800	63.33	0.544
	5th surface					_	8 9	-9.168	0.89	1.72047	34.71	0.583
	k = -0.985						9 10(Stop)	8.096 ∞	1.17 1.16			
	A4 = -4.58140	e-06					11	-9.133	0.89	1.72047	34.71	0.583
	8th surface					_	12	13.575	1.99	1.61800	63.33	0.544
	k = 0.000					55	13 14*	-13.167 35.940	0.10 1.45	1.49700	81.61	0.538
	A4 = 3.12616e	-05					15*	-35.021	0.10	1,,,,,,,	01.01	0.550
	16th surface					_	16*	9.242	1.85	1.49700	81.61	0.538
	k = -0.579						17* 18*	17.291 14.145	2.09 2.00	1.63490	23.88	0.630
	A4 = -0.379 A4 = -1.17288	8e-04				60	19*	-39.253	5.67	1.03470	23.00	0.030
	17th surface					60	20*	-5.955	0.70	1.53368	55.90	0.563
	1- 0.000						21*	-14.900	2.22	1 52260	55.00	0.562
	k = 0.000 A4 = -4.12749	e-05					22* 23*	-5.519 -70.863	0.90 1.20	1.53368	55.90	0.563
	18th surface					_	24	œ	0.38	1.51640	65.06	0.535
						_	25	00	0.30			
	k = 0.000					65	Image plane	∞	0.50			

148 Example 21

Aspherical surface data	5	_ 5 Unit mm								
1st surface		Surface data								
k = 0.000 A4 = 1.50492e-04, A6 = -3.54780e-06	_	Surface no.	r	d	nd	νd	θ			
2nd surface		1*	37.191	2.51	1.84666	23.77	0.0			
k = -2.669	10	2*	-60.365	0.10	1.502.64	20.20				
A4 = 2.22005e-04, $A6 = -2.69213e-06$		3* 4*	45.462 17.208	0.70 0.10	1.58364	30.30	0.:			
3rd surface		5*	14.316	4.65	1.49700	81.61	0.			
k = 0.000		6	-53.760	0.10						
A4 = 3.10091e - 04	15	7 8*	23.156 -23.670	3.55 0.10	1.49700	81.61	0.:			
4th surface		9	22.799	2.41	1.61800	63.33	0.			
k = 0.000		10	-29.442	0.70	1.72047	34.71	0.:			
A4 = -3.25978e - 04		11	7.650	1.45						
5th surface		12(Stop)	∞ -25.486	1.07	1 72047	3471	0			
	20	13 14	-25.486 7.699	0.70 2.32	1.72047 1.61800	34.71 63.33	0.:			
k = -1.313	20	15	50.679	0.10	1.01000	05.55	٧			
A4 = -2.31327e-04, A6 = 3.63551e-06 6th surface		16*	12.228	2.01	1.49700	81.61	0.3			
6th surface		17*	98.730	16.81		0.				
k = -1.763		18*	31.846	6.30	1.49700	81.61	0.:			
A4 = 1.38063e-04, A6 = -2.69269e-07	2.5	19* 20*	-77.563 14.198	2.03 3.25	1.63490	23.88	0.0			
14th surface	25	21*	201.898	3.23 4.35	1.03490	23.00	0.			
		22*	-12.028	0.70	1.53368	55.90	0.5			
k = -0.579		23*	20.065	1.37						
A4 = 1.44838e-04, A6 = -1.01594e-06 15th surface		24*	34.840	0.70	1.53368	55.90	0.			
13th surface		25*	16.829	1.23	1.51.640		0			
k = 0.000	30	26 27	& &	0.38 0.30	1.51640	65.06	0.3			
A4 = 2.79291e-04, A6 = -6.60640e-07 16th surface		Image plane	∞	0.30						
k = 0.000			Asphe	rical surfa	ce data					
A4 = 1.42801e-04, A6 = 2.79003e-07 17th surface	35		1st su	rface						
			k = 0.0	000						
k = 0.000				-000 -2.94380€	-05					
A4 = -1.94371e-04, A6 = 1.98964e-06 18th surface			2nd su							
			k = -3	22.025						
k = -2.995	40			6.14622e-	-06					
A4 = 2.02338e-04, A6 = -3.03901e-06 19th surface			3rd su							
			k = 0.0	000						
k = 0.000				-1.753466	e-07					
A4 = 3.16281e-04, A6 = -2.16676e-06 20th surface	4.5		4th su	rface						
	45		k = 0.0	000						
k = 0.000				-4.72517e	e-05					
A4 = 1.23235e-03			5th su	rface						
21th surface			k = -0),524						
k = 0.000	50			-1.41649e	=-05					
A4 = 7.37586e-04	50		8th su							
22th surface			1 -	7 007						
			k = -7 $A4 = 7$	7.887 1.22953e-	-05					
k = 0.000			16th s		<i>VJ</i>					
A4 = 1.78231e-04										
23th surface	55		k = -0							
k = -207.247				2.95007e-	-05					
A4 = -9.71403e - 04, $A6 = -5.03108e - 06$			17th s	uriace						
Various data			k = 0.0		. 05					
various data	60		A4 = - 18th s	–2.68357e urface	:-05					
JA 0.23										
Magnification -1.33			k = 0.0							
focal length 5.76				6.31745e-	-05					
mage height (mm) 4.92			19th s	urface						
b (mm) (in air) 1.75	65		k = 0.0	_ _		<u></u>				
ens total length (mm) (in air) 36.60										

	-0	continue	ed				-continued	
		Unit mm					Unit mm	
	20th sı	urface				- <u></u>	Aspherical surface data	
	k = 0.0 $A4 = 6$ $21th si$	5.62069e-	-06			_	1st surface	
	k = 0.0)00 -5.81516e	÷−05			10	k = 0.000 A4 = 4.20748e-06 2nd surface	
	k = 0.0)00 13853e-	-04			_	k = 0.000 A4 = 1.02174e-05 5th surface	
	k = 0.0 A4 = - 24th si	-1.70151e	÷-04			15	k = 0.362 A4 = -1.39316e-06 8th surface	
	$k = 0.0$ $A4 = -\frac{25 \text{th so}}{2}$	-3.46508e	e-04			20	k = 0.000 A4 = 7.34221e-05 16th surface	
		-8.40323e				-	k = -0.579 $A4 = -1.11345e - 04$	
Foca Ima	gnification al length ge height (mm) nm) (in air)	arious dat	ta.	0.23 -1.33 11.95 4.92		_ 25	17th surface k = 0.000 A4 = -3.97260e-04 18th surface	
	s total length (mm	n) (in air)		1.78 59.87		30	k = 0.000 A4 = 3.14959e-04 19th surface	
	Ех	ample 2	22			35	k = 0.000 A4 = 9.18979e-04 20th surface	
		Unit mm				-	k = 0.000 A4 = -3.01972e-04	
	Si	urface dat	a			-	21th surface	
Surface no.	r	d	nd	v d	θgf	40	k = 0.000 A4 = 1.22286e-04	
1* 2*	19.718 57.140	2.47 0.10	1.84666	23.77	0.620		22th surface	
3 4 5*	28.082 15.535	0.70 0.71	1.65412 1.49700	39.68	0.574	45	k = 0.000 A4 = 3.61097e - 10	
5* 6 7	16.135 -111.432 12.560	3.81 0.10 3.28	1.49700	81.61 81.61	0.538		23th surface k = 0.000	
8* 9 10 11	9264.110 23.767 -17.820 14.919	0.10 2.95 0.70 0.94	1.61800 1.72047	63.33 34.71	0.544 0.583	50	A4 = -2.33784e-10 24th surface	
12(Stop) 13 14	∞ 36.855 6.199	-0.22 0.70 2.19	1.90366 1.61800	31.32 63.33	0.595 0.544		k = 0.000 A4 = 7.88303e-11 25th surface	
15 16* 17*	13.800 7.064 -1661.525	0.10 3.86 5.38	1.49700	81.61	0.538	55	k = 0.000	
18* 19* 20*	-7.343 26.316 14.001	0.70 2.07 4.50	1.49700 1.58364	81.61 30.30	0.538		A4 = -9.83303e-04, A6 = -4.80768e-06	
21* 22*	-8.579 -9.265	3.08 0.70	1.49700	81.61	0.538	60	Various data	
23* 24* 25*	10.893 -15.074 -20.788	2.23 1.42 0.76	1.53368	55.90	0.563	0.0	NA 0.23 Magnification -1.33 Focal length 9.09	
26 27	& &	0.38 0.30	1.51640	65.06	0.535		Image height (mm) 4.92 fb (mm) (in air) 1.31	
Image plane	∞					65	Lens total length (mm) (in air) 43.88	

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								· ·	Jnit mm			
	U:	nit mm				- 5		24th surface				
	~	c 1.				•		k = 0.000				
Surface no.	r	face data d	nd	vd	θgf	-		A4 = -4.02512e - 11 25th surface				
						•		k = 0.000				
1	21.347	0.70	1.83400	37.16	0.577	10		A4 = 1.98197e - 11				
2 3	19.857 82.525	2.68 0.10	1.84666	23.77	0.620			26th surface				
4	28.223	0.70	1.65412	39.68	0.574							
5	13.598	0.10						k = 0.000				
6*	13.218	4.13	1.49700	81.61	0.538			A4 = -7.91121e - 04	1, A6 = -7	.74500e-06		
7	-426.276	0.10				1.5		Vo	rious data	1		
8	12.661	3.24	1.49700	81.61	0.538	15		***	arous dan			
9 * 10	-620.123 23.276	0.10 3.03	1.61900	63.33	0.544		1	NA			0.23	
10	-15.973	0.70	1.61800 1.72047	34.71	0.583		1	Magnification			-1.33	
12	14.351	0.70	1.72047	34.71	0.565			Focal length			8.95	
13(Stop)	∞	-0.12						Image height (mm)			4.92	
14	52.229	0.70	1.90366	31.32	0.595	20		fb (mm) (in air)			2.12	
15	6.517	2.05	1.61800	63.33	0.544		I	Lens total length (mm)) (in air)		44.87	
16	14.011	0.10										
17*	7.279	3.70	1.49700	81.61	0.538							
18*	-52.147	6.22						Γ_{Σ}	ample 2	4		
19*	-8.485	0.70	1.49700	81.61	0.538			£X	ampie 2	·¬		
20*	18.496	2.19				25						
21*	16.238	3.38	1.58364	30.30	0.599							
22*	-8.208	3.48										
23*	-14.030	0.80	1.49700	81.61	0.538			Ţ	Jnit mm			
24*	10.694	2.34										
25*	-13.561	0.70	1.53368	55.90	0.563			Su	rface data	ı		
26*	-32.525	1.56				30	G C			4	1	0 - 0
27	00	0.38	1.51640	65.06	0.535		Surface no.	r	d	nd	νd	θ gf
28	∞	0.30					1*	29.347	3.01	1.84666	23.77	0.620
Image plane	∞						2*	-36.004	0.10	1.0 1000	23.77	0.020
						•	3	-397.741	0.70	1.65412	39.68	0.574
	Aspheric	al surfac	e data			35	4	21.124	0.10			
	6:1 6					•	5*	19.426	4.27	1.49700	81.61	0.538
	6th surface					_	6	-31.982	0.10			
	k = 0.102						7	20.342	3.53	1.49700	81.61	0.538
	A4 = -3.11348e - 06						8* 9	-22.961 -172.666	0.10 2.93	1.61800	63.33	0.544
	9th surface						10	-11.505	0.70	1.72047	34.71	0.583
	Jul Surface					- 40	11	24.226	0.79	1.72047	37.71	0.505
	k = 0.000						12(Stop)	∞	0.17			
	A4 = 7.09963e - 05						13	-243.374	0.70	1.90366	31.32	0.595
	17th surface						14	9.660	3.41	1.61800	63.33	0.544
						-	15	-43.351	0.10			
	k = -0.579					45	16*	11.180	4.50	1.49700	81.61	0.538
	A4 = -1.62833e - 04					43	17*	-10186.757	8.48	4 40700	04.64	0.530
	18th surface						18*	719.997	0.70	1.49700	81.61	0.538
						-	19* 20*	13.006	6.32	1.58364	30.30	0.599
	k = 0.000						21*	13.192 -15.080	3.44 3.70	1.50504	50.50	0.333
	A4 = -2.59299e - 04						22*	-9.430	0.81	1.49700	81.61	0.538
	19th surface					50	23*	10.877	2.39			
							24*	-10.747	0.51	1.53368	55.90	0.563
	k = 0.000						25*	-3339.876	1.95			
	A4 = 2.69659e - 05						26	∞	0.38	1.51640	65.06	0.535
	20th surface						27	∞	0.30			
						_	Image plane	∞				
	k = 0.000					55		A auch aud	1	a data		
	A4 = 5.59803e-04							Aspnen	cal surfac	e data		
	21th surface					-		1st surface				
	k = 0.000							k = 0.000				
	A4 = -2.63419e - 04 22th surface					60		A4 = 1.00145e-05 2nd surface				
	k = 0.000							1 0000				
	A4 = 1.85257e - 04							k = 0.000				
	23th surface							A4 = 4.66734e-05 5th surface				
								2.11.0011000				
	k = 0.000					65		k = 0.699				
	A4 = 1.30466e-10							K = 0.022				

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-continued
-commuca

		TT '4				-			TT 11			
		Unit mm				-	12/2:		Unit mm			
	8th surface					- 5	12(Stop) 13	∞ 213.328	0.42 0.70	1.90366	31.32	0.59
	k = 0.000						14	9.662	3.29	1.61800	63.33	0.54
	A4 = 8.05284e - 05						15	-95.685	0.10			
	16th surface					_	16* 17*	11.359 192.634	4.50 12.20	1.49700	81.61	0.53
	k = -0.579						18*	-46.287	0.70	1.49700	81.61	0.53
	A4 = 7.50799e - 06					10	19*	55.888	3.89			
	17th surface					_	20*	15.242	3.43	1.58364	30.30	0.59
	k = 0.000						21* 22*	-12.872 -9.883	3.53 0.70	1.49700	81.61	0.53
	A4 = -8.03928e - 03928e	5					23*	10.330	2.47	1.49700	81.01	0.55
	18th surface	_					24*	-8.858	0.47	1.53368	55.90	0.56
						15	25*	38.821	2.50			
	k = 0.000						26	∞	0.30	1.51640	65.06	0.53
	A4 = -2.62042e - 0.4 19th surface	4					27 Image plane	& &	0.30			
	k = 0.000					_		Aspher	rical surfa	ce data		
	A4 = 2.02927e-08 20th surface					20		1st surface				
	k = 0.000							k = 0.000				
	A4 = 1.22996e - 05							A4 = -8.60855e - 0	6			
	21th surface					_		2nd surface				
	l- 0.000					25		k = 0.000				
	k = 0.000 A4 = 1.31433e-04							A4 = 5.67857e - 05				
	22th surface							5th surface				
						_						
	k = 0.000							k = -0.732				
	A4 = 1.29005e-10 23th surface					30		A4 = 8.88649e - 05 8th surface				
	23th surface							om surface				
	k = 0.000							k = 0.000				
	A4 = -8.96164e - 1	1						A4 = 9.71863e - 05				
	24th surface					_		16th surface				
	k = 0.000					35		k = -0.579				
	A4 = 3.63415e - 11					33		A4 = 3.62332e - 05				
	25th surface					_		17th surface				
	k = 0.000							k = 0.000				
	A4 = -8.06302e - 04	4. A6 = -	6.85664e=06	i				A4 = -4.68359e - 0	5			
						- 40		18th surface				
	V	arious da	ta			-10		1 0000				
,	NA			0.38		-		k = 0.000 A4 = -3.90596e - 0	4			
	Magnification			-2.20				19th surface	7			
	Focal length			5.02								
	Image height (mm)			4.92		45		k = 0.000				
	fb (mm) (in air)	A (!!-A		2.50		43		A4 = 5.65832e - 09				
1	Lens total length (mm	1) (in air)		54.08		_		20th surface				
								k = 0.000				
								A4 = 1.29627e - 04				
	Ex	ample	25			50		21th surface				
						30		k = 0.000				
								A4 = 2.61604e - 04				
						-		22th surface				
		Unit mm				_		k = 0.000				
	Sı	urface dat	ta —			_ 55		A4 = 6.73337e - 11				
urface no.	r	d	nd	νd	θgf	_		23th surface				
1*	32.463	2.90	1.84666	23.77	0.620	-		k = 0.000				
2*	-21.826	0.10						A4 = -2.85935e - 1 24th surface	U			
3	-115.439	0.70	1.65412	39.68	0.574	60		ZTIII SIII IACE				
4	19.615	0.71	1 40700	01 /1	0.530	00		k = 0.000				
€ ak			1.49/00	81.61	0.538			A4 = -1.78374e - 1	1			
	-24.111 34.797		1.49700	81.61	0.538			25th surface				
6		0.10										
5* 6 7 8*	-16.663	0.10						1 0.000				
6 7 8* 9	-16.663 -45.805	3.04	1.61800	63.33	0.544	e =		k = 0.000				
	22.162 -24.111 34.797	3.86 0.10 3.13 0.10	1.49700 1.49700	81.61 81.61	0.538			A4 = -1.78374e - 1 25th surface	1			
6 7 8*	-16.663		1.61800 1.72047	63.33 34.71	0.544 0.583	65		A4 = -1.17807e - 0	3 16 -	1 38777 - 04		

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	-c	ontinue	ed					-0	ontinue	ed		
	,	Unit mm							Unit mm			
	V	arious dat	ta			_ 5	18th	surface				
Ma Foo Im: fb	NA 0.43 Magnification -2.55 Focal length 4.06 Image height (mm) 4.92 fb (mm) (in air) 3.00 Lens total length (mm) (in air) 55.41						$A4 = \frac{19th}{k}$ $k = 0$ $A4 = \frac{1}{2}$	0.000 = -9.44986e-0 surface 0.000 = 2.20099e-08				
	Ex	ample	26			15	k = 0 A4 = 21th k = 0	0.000 = -2.09970e-0 surface 0.000 = 1.31063e-04				
		Unit mm				-		surface				
	g.	C				-		0.000	_			
~ 2		ırface dat				- 20		= -4.92137e-1 surface	1			
Surface no		d	nd	νd	θgf	_		0.000				
1*	35.723	2.54	1.84666	23.77	0.620			= -3.04317e-1	0			
2* 3	-51.097 36.176	0.10 0.71	1.65412	39.68	0.574		24th	surface				
4	20.906	0.70	1.05412	39.00	0.574	25	le (0.000				
5*	23.037	3.88	1.49700	81.61	0.538			= -4.31877e-1	2			
6	-48.688	0.10						surface	_			
7	28.972	4.09	1.49700	81.61	0.538		2541	surace				
8*	-14.465	0.10					k = 0	0.000				
9	-30.479	2.71	1.61800	63.33	0.544		A4 =	= -1.03058e-0	3, A6 = -3	5.12548e-06	5	
10	-11.008	0.70	1.72047	34.71	0.583	30 🕳						
11	-45.001	0.00						V	arious dat	a		
12(Stop)	00	0.36				-						
13	142.278	0.70	1.90366	31.32	0.595		NA				0.40	
14	7.974	3.29	1.61800	63.33	0.544			fication			-2.55	
15 16*	42.037 9.420	0.10 4.50	1.49700	81.61	0.538		Focal l				4.53	
17*	50,449	11.08	1.49700	01.01	0.556	35		height (mm)			4.92	
18*	-10.686	0.70	1.49700	81.61	0.538			n) (in air) otal length (mn	a) (in air)		1.71 51.12	
19*	14.658	2.13	21.0.00			_	Lensit	otar rength (mi	1) (111 411)		31.12	
20*	8.921	3.26	1.58364	30.30	0.599							
21*	-11.441	2.20						Ex	ample 2	27		
22*	-6.836	0.70	1.49700	81.61	0.538	40		L.A	ampie 2	21		
23*	17.063	2.85										
24* 25*	-7.530	1.89	1.53368	55.90	0.563							
26	-23.262 ∞	1.20 0.30	1.51640	65.06	0.535	-						
27	∞ ∞	0.30	1.31040	03.00	0.555				Unit mm			
Image plan		0.51				-		-	C 1.4			
mage plan						_ 45 _			urface dat	a		
	Aspher	ical surfa	ce data			_	Surface no.	r	d	nd	νd	$\theta g f$
<u>.</u>	1st surface						1*	35.661	2.32	1.84666	23.77	0.620
1	k = 0.000						2*	-73.499	0.43	1.40700	01.61	0.530
	A4 = 2.15858e - 05					50	3*	34.183	4.48	1.49700	81.61	0.538
	2nd surface					~~	4 5	-54.877	0.10	1.40700	Q1 £1	0.529
-						_	5 6*	25.768 -15.284	4.00 0.10	1.49700	81.61	0.538
1	k = 0.000						7	-13.284 -32.854	2.97	1.61800	63.33	0.544
	A4 = 5.89518e - 05						8	-10.053	0.70	1.72047	34.71	0.583
	5th surface					_	9	-46.051	0.05	22017	J, 1	0.000
-						55	10(Stop)	∞	0.47			
	k = 1.031						11	635.573	0.70	1.90366	31.32	0.595
	A4 = 4.92091e-05						12	8.195	3.10	1.61800	63.33	0.544
-	8th surface					_	13	42.918	0.10			
1	k = 0.000						14*	9.414	4.50	1.49700	81.61	0.538
	A4 = 1.43893e - 04						15* 16*	63.321	11.58	1.40700	Q1 Z1	0.529
	16th surface					60	16* 17*	-9.781	0.70	1.49700	81.61	0.538
-						_	1/* 18*	27.718 9.851	2.51 3.31	1.58364	30.30	0.599
1	k = -0.579						19*	-11.040	2.20	1.50504	50.50	V.J77
	A4 = 1.23991e - 05						20*	-7.575	0.70	1.49700	81.61	0.538
:	17th surface					_	21*	13.961	2.79		_1.01	
•						65	22*	-8.162	1.28	1.53368	55.90	0.563
	k = 0.000					65	23*	-48.156	1.52			
4	A4 = -1.44605e - 04	4					24	∞	0.30	1.51640	65.06	0.535

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5 ∞ 0.31				TT 1:			
nage plane ∞	5			Unit mm			
Aspherical surface data			S	Surface dat	a		
1st surface		Surface no.	r	d	nd	νd	θg
	10	1*	26.126	2.52	1.84666	23.77	0.62
k = 0.000		2* 3*	156.726 19.398	0.44 3.22	1.49700	81.61	0.53
A4 = 3.30814e - 05		4	668.362	0.10	1.49700	61.01	0.55
2nd surface		5	22.441	4.29	1.49700	81.61	0.53
k = 0.000		6*	-18.521	0.10			
A4 = 7.07042e - 05		7	-32.011	3.31	1.61800	63.33	0.54
3rd surface	15	G	-10.629	0.70	1.72047	34.71	0.58
5rd surface		9	-32.981	-0.18			
k = 7.049		10(Stop)	oo 5.4.460	0.91	1.00266	21.22	0.50
A4 = 5.92848e - 05		11	-54.468	0.70	1.90366	31.32	0.59
6th surface		12	10.084	3.88	1.61800	63.33	0.54
our surface		13 14*	-38.832 11.830	5.09 4.50	1.49700	81.61	0.53
k = 0.000	20	15*	32.748	6.33	1.49700	61.01	0.55
A4 = 1.66928e - 04		16*	-51.536	0.70	1.49700	81.61	0.53
14th surface		17*	-5076.695	1.50	1.15700	01.01	0.00
1-til stillace		18*	16.498	4.50	1.58364	30.30	0.59
k = -0.579		19*	-18.479	2.95	,		
A4 = 1.76892e - 05	25	* * *	-13.897	0.70	1.49700	81.61	0.53
15th surface	20	21*	14.288	2.43			
15 di Stillaco		22*	-9.910	0.50	1.53368	55.90	0.56
k = 0.000		23*	19.020	1.20			
A4 = -1.15869e - 04		24	œ	0.30	1.51640	65.06	0.53
16th surface		25	8	0.31			
Total Bulliace	30	Image plane	∞				
k = 0.000			A 1				
A4 = -1.90405e - 04			Aspne	rical surfa	ce data		
17th surface			1st surface				
-			15t Salitace				
k = 0.000	35		k = 0.000				
A4 = 4.29668e - 08	33		A4 = 4.45476e - 05	5			
18th surface			2nd surface				
1 0000			k = 0.000				
k = 0.000			A4 = 4.21609e - 0.5				
A4 = -1.26564e - 04			3rd surface	,			
19th surface	40		31d surface				
1. 0.000			k = 1.630				
k = 0.000			A4 = -6.68631e - 0)5			
A4 = 2.29008e - 04			6th surface				
20th surface							
	45		k = 0.000				
k = 0.000	73		A4 = 1.02748e - 04	1			
A4 = -5.43091e - 12			14th surface				
21th surface							
			k = -0.579				
k = 0.000			A4 = -5.95923e - 0)5			
A4 = -1.28275e - 10	50		15th surface				
22th surface					_		
			k = 0.000				
k = 0.000			A4 = -1.92311e - 0)4			
A4 = -4.59881e - 11			16th surface				
23th surface			l 0.000				
	55		k = 0.000	14			
k = 0.000			A4 = -2.60712e - 0 17th surface	/ -1			
A4 = -1.00347e - 03, $A6 = -7.29887e - 06$			17th Stifface				
Vo::			k = 0.000				
Various data			A4 = 3.61925e - 09)			
	60		18th surface				
NA 040			_				
NA 0.40							
Magnification -2.55			k = 0.000				
Magnification -2.55 Focal length 4.30			k = 0.000 A4 = 6.14546e - 0.7	7			
Magnification -2.55 Focal length 4.30 Image height (mm) 4.92				7			
Magnification -2.55 Focal length 4.30			A4 = 6.14546e - 07	7			

	-		-continued										
		Unit mm							Unit mm				
	20th surface					 - 5	3rd s	surface					
	k = 0.000 A4 = 7.96105e-1 21th surface	1				_	A4 =	1.920 = -6.92724e-0 surface)5				
	k = 0.000 A4 = 1.79636e-10 22th surface	0				10	A4 =	k = 0.000 A4 = 1.06996e-04 14th surface					
	k = 0.000 A4 = 2.08521e-10 23th surface	0					A4 =	-0.579 = -5.87534e-0 surface)5				
	k = 0.000 $A4 = -7.36017e - 6$	04, A6 = 1	.85128e-08			- 15 -	A4 =	0.000 = -1.97727e-0 surface)4				
	٦	Various da	ta			_		0.000					
]	NA			0.40		20		= -3.03525e-0 surface)4				
]] i	Magnification -1.60 Focal length 5.39 Image height (mm) 4.92 fb (mm) (in air) 1.71 Lens total length (mm) (in air) 50.89						k = 0.000 A4 = 2.27302e-08 18th surface						
	Lens total length (m	_ 25	k = 0.000 A4 = 1.91296e-05 19th surface										
	E	30	A4 =	0.000 = 1.02712e-04 surface									
Unit mm							A4 =	0.000 = 9.87048e-11					
	Surface data						<u>21th</u>	surface					
Surface no.	T 25 722	d	nd	vd	θgf	35	A4 =	0.000 = 9.22769e–11 surface					
2*	25.723 149.616	3.03 0.54	1.84666	23.77	0.620			0.000					
3* 4	19.523 156.580	3.74 0.10	1.49700	81.61	0.538	40		= 9.06991e-11 surface					
5	20.438	3.50	1.49700	81.61	0.538	40							
6 * 7	-18.183 -28.405	0.15 3.65	1.61800	63.33	0.544			0.000 = -8.67255e-0)4, A6 = 8	.57757e-07			
8 9	-10.074 -29.736	0.70	1.72047	34.71	0.583	_							
9 0(Stop)	-29.730 ∞	0.03 0.98				_			/arious da	ta			
1	-37.887	0.70	1.90366	31.32	0.595	45	NA				0.31		
.3	10.973 -29.734	3.19 5.20	1.61800	63.33	0.544		Magnii Focal l	fication			-1.56 5.41		
4*	11.850	4.46	1.49700	81.61	0.538		Image	height (mm)			4.92		
.5* .6*	32.907 -43.174	6.37 0.70	1.49700	81.61	0.538			n) (in air) otal length (mr	n) (in ain)		1.70 50.87		
.7*	-583.895	1.39				50 -	Lensit	om tengtii (illi	ы) (ш аш)		JV.01		
.8* .9*	16.200 -16.507	4.17 2.96	1.58364	30.30	0.599								
.9 !0*	-13.189	0.70	1.49700	81.61	0.538			Es	kample	30			
1*	14.167	2.41						<i>L1</i>		_ •			
2* 3*	-9.282 18.028	0.50 1.20	1.53368	55.90	0.563	55							
4	∞	0.30	1.51640	65.06	0.535	55							
25 maga plana	& &	0.31							Unit mm				
mage plane								S	urface da	ta			
	Asphe	erical surfa	ce data				Surface no.	r	d	nd	vd	θgf	
	1st surface					60	1*	19.930	3.24	1.84666	23.77	0.620	
	k = 0.000						2*	61.126	0.64	1.04000	23.11	0.020	
	A4 = 4.82416e - 03	5					3*	20.022	2.36	1.49700	81.61	0.538	
	2nd surface					_	4 5	64.679 14.877	0.10 3.79	1.49700	81.61	0.538	
	k = 0.000 A4 = 4.12737e-03	5				65	6* 7	-20.728 -22.514	0.44 2.78	1.61800	63.33	0.544	

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-continue	1
-continue	1

		Unit mm							Unit mm			
8	-8.591 -28.840	0.70 0.09	1.72047	34.71	0.583	 5		ge height (mm) nm) (in air)			4.92 1.70	
10(Stop)	-28.840 ∞	0.69						total length (mm) (in air)		50.72	
10(Stop) 11	-75.968	0.70	1.90366	31.32	0.595	_	Lens	totai iengin (iiiii	i) (m an)		30.72	
12	10.025	3.17	1.61800	63.33	0.544	_						
13	-47.134	7.43	1.01000	05.55	0.544							
14*	11.048	4.18	1.49700	81.61	0.538			Ev	ample 3	3.1		
15*	29.122	8.18				10		LA	ampie.	<i>,</i> 1		
16*	16.083	3.74	1.58364	30.30	0.599							
17*	-23.253	3.00										
18*	-11.275	0.70	1.49700	81.61	0.538	_						
19*	22.496	2.40							Unit mm			
20*	-8.030	0.70	1.53368	55.90	0.563	-						
21*	19.993	1.20				15 _		Sı	ırface dat	a		
22	∞	0.30	1.51640	65.06	0.535					_		
23	∞	0.31					Surface no.	r	d	nd	vd	θ gf
Image plane	∞					_	4.16	22.255	1.10	1.01666	22.77	0.60
						-	1*	22.255	1.40	1.84666	23.77	0.620
	Aspher:	ical surfac	ce data				2* 3*	49.454	0.10	1.40700	01 61	0.529
						- 20	3* 4	15.934 49.074	1.56 0.10	1.49700	81.61	0.538
1st s	urface						5	49.074 8.678	2.60	1.49700	81.61	0.538
						-	5 6*	8.078 24.865	0.10	1.79/00	01.01	0.55
k = 0	0.000						7	16.464	2.59	1.62041	60.29	0.543
	= 5.96209e-05						8	-16.180	0.71	1.72047	34.71	0.54
	surface						9	20.086	0.50	1.72077	5-1.71	0.50.
2110	Juliu00					- 25	10(Stop)	20.080	-0.14			
b = 0	0.000						10(Stop) 11	16.335	0.77	1.90366	31.32	0.59
	= 4.52358e-05						12	4.955	2.54	1.62041	60.29	0.543
	= 4.32336e-03						13	13.367	0.10	2.02011	00.22	1.
310 8	ourrace					_	14*	8.375	3.54	1.49700	81.61	0.538
1- 1	3.494						15*	12.841	5.26			
		1				30	16*	18.465	1.08	1.49700	81.61	0.538
	= -1.04703e-04	٠					17*	20.987	1.60			
oth s	surface					_	18*	17.258	3.54	1.58364	30.30	0.599
1 .	2.000						19*	-13.619	2.16			
	0.000						20*	-7.110	0.80	1.49700	81.61	0.538
	= 1.16629e-04						21*	6.864	4.38			
14th	surface					- 35	22*	38.244	1.35	1.53368	55.90	0.563
						55	23*	40.675	1.79			
	-0.579						24	∞	0.38	1.51640	65.06	0.535
	= -1.22009e-05	5					25	∞	0.31			
15th	surface	_				_	Image plane	∞				
, ,						-		a 1	:1- C	1-4.		
k = 0	0.000					40		Aspher	ical surfa	ce data		
	= 9.35253e-06					_	1.44	t surface				
						_	18	i surrace				
	surface						1 _e _					
<u>16th</u>								= 0.000				
$\frac{16\text{th}}{k} = 0$	0.000							= 0.000 4 = 9.39832e-05				
$\frac{16\text{th}}{k} = 0$ $A4 = 0$	0.000 = -4.21205e-05	5					A	4 = 9.39832e - 05				
$\frac{16\text{th}}{k} = 0$ $A4 = 0$	0.000	5				_ 45	A					
k = 0 $A4 = 17th$	0.000 = -4.21205e-05 surface	5				_ 45	A ² 2n	4 = 9.39832e - 05				
k = 0 $A4 = 17th$ $k = 0$	0.000 = -4.21205e-05 surface	5				_ 45	A4 2n k =	4 = 9.39832e-05 d surface				
16th k = 0 A4 = 17th k = 0 A4 = 0	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05	5				_ 45	A	4 = 9.39832e-05 d surface = 0.000				
16th k = 0 A4 = 17th k = 0 A4 = 0	0.000 = -4.21205e-05 surface	5				_ 45	A	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05				
16th k = 0 A4 = 17th k = 0 A4 = 18th	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface	5				_ 45	A4 2n k = A4 3rd k =	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034				
16th k = 0 A4 = 17th k = 0 A4 = 18th	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface	<u>-</u>				_ 45 _ _ 50	A ² 2n k = A ² 3re k =	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-03	5			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 18th	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04	5				_	A ² 2n k = A ² 3re k =	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034	5			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 4	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface	5				_	A-2 2n k = A-2 3rc k = A-2 6tl	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-0:	5			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19th	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface	5				_	A-2 2n k = - A-2 3rc k = - A-2 6tl k = -	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-00 h surface = 0.000	5			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h :	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface	5				_	A-2 2n k = A-2 3rc k = A-4 6tl k =	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-00 h surface = 0.000 4 = 2.34844e-04	5			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h : k = 0 A4 = 0	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04	5				_	A-2 2n k = A-2 3rc k = A-4 6tl k =	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-00 h surface = 0.000	5			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h : k = 0 A4 = 0	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface	5				_	A-2 2n k = A-4 3rd 4-4 6tl k = A-2 14	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-09 h surface = 0.000 4 = 2.34844e-04 th surface	5			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h : k = 0 A4 = 20th	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface	5				50	A-2 2n k = A-4 3rc k = A-2 6tl k = A-4 14	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-0: h surface = 0.000 4 = 2.34844e-04 th surface = -0.579				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h: k = 0 A4 = 20th	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface	5				50	A-2 2n k = A-4 3rc k = A-2 6tl k = A-4 14	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-03 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-04				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h: k = 0 A4 = 20th k = 0 A4 = 4	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 3.296805e-04 surface	5				50	A-2 2n k = A-4 3rc k = A-2 6tl k = A-4 14	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-0: h surface = 0.000 4 = 2.34844e-04 th surface = -0.579				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h: k = 0 A4 = 20th k = 0 A4 = 4	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface	5				50	A-2 2n k = A-4 3rc 6tl k = A-4 14 k = A-2 15	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-09 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-04 th surface				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h: k = 0 A4 = 20th k = 0 A4 = 4	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 3.296805e-04 surface	5				50 - 55	A-2 2n k = A-4 3r A-4 6t1 k = A-2 14 k = A-2 15	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-03 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-03 th surface = 0.000				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h: k = 0 A4 = 20th k = 0 A4 = 4	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 8.17176e-05 surface	5				50	A-2 2n	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-03 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-04 th surface = 0.000 4 = 9.62591e-05				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h : capacitate A4 = 20th k = 0 A4 = 21th k = 0	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 8.17176e-05 surface		86063e-07			50 - 55	A-2 2n	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-03 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-03 th surface = 0.000				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h : capacitate A4 = 20th k = 0 A4 = 21th k = 0	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 8.17176e-05 surface		.86063e-07			50 - 55	A-2 2n k = A-4 3rc 6tl k = A-2 14 k = A-2 15 k = A-2 16	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-03 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-04 th surface = 0.000 4 = 9.62591e-05 th surface				
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h : capacitate A4 = 20th k = 0 A4 = 21th k = 0	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 8.17176e-05 surface 0.000 = 8.17176e-05 surface					50 - 55	A-2 2n k = A-4 3rd 6t1 k = A-4 14 k = A-4 15 k = A-6 A-6 A-6 A-6 A-6 A-6 A-6 A-6	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-09 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-04 th surface = 0.000 4 = 9.62591e-05 th surface = 0.000	4			
16th k = (A4 = 17th k = (A4 = 18th k = (A4 = 19h: k = (A4 = 20th k = (A4 = 21th k = (A4 =	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 8.17176e-05 surface 0.000 = 8.17176e-05 surface	4, A6 = 7.				50 - 55	A-2 2n k = A-4 3rn k = A-2 6tl k = A-2 1-4 k = A-2 1-5 k = A-2 1-6 k = A-2 1-6 k = A-2 1-6 k = A-2 1-6 k = A-2 1-6	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-03 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-04 th surface = 0.000 4 = 9.62591e-05 th surface	4			
16th k = 0 A4 = 17th k = 0 A4 = 18th k = 0 A4 = 19h : c A4 = 20th k = 0 A4 = 21th k = 0 A4 = 19th	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 8.17176e-05 surface 0.000 = -6.90519e-04	1 , A6 = 7.		0.31		50 - 55 - 60	A-2 2n k = A-4 3rn k = A-2 6tl k = A-2 1-4 k = A-2 1-5 k = A-2 1-6 k = A-2 1-6 k = A-2 1-6 k = A-2 1-6 k = A-2 1-6	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-09 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-09 th surface = 0.000 4 = 9.62591e-05 th surface = 0.000 4 = -2.20378e-09	4			
16th k = (A4 = 17th k = (A4 = 18th k = (A4 = 19h : k = (A4 = 20th k = (A4 = 21th k = (A4 =	0.000 = -4.21205e-05 surface 0.000 = 3.29945e-05 surface 0.000 = 2.14586e-04 surface 0.000 = 2.96805e-04 surface 0.000 = 8.17176e-05 surface 0.000 = -6.90519e-04	1 , A6 = 7.		0.31 -1.55		50 - 55	A-2 2n k = A-4 3re 6tl k = A-4 14 k = A-4 15 k = A-4 16 k = A-4 17	4 = 9.39832e-05 d surface = 0.000 4 = 2.63124e-05 d surface = 1.034 4 = -8.38701e-09 h surface = 0.000 4 = 2.34844e-04 th surface = -0.579 4 = -1.61090e-09 th surface = 0.000 4 = 9.62591e-05 th surface = 0.000 4 = -2.20378e-09	4			

8

1st surface

k = 0.000

A4 = 6.50944e - 05

Image plane

Aspherical surface data

	_	163	.d						164			
	-(continue	eu –			_			-contin	lueu		
		Unit mm				_			Unit n	ım		
<u>18th</u>	surface					- 5		2nd surface				
A4 =	0.000 = 5.22295e-05 surface					_		k = 0.000 A4 = 5.45929e- 3rd surface	-05			
A4 =	0.000 = -1.67837e-0 . surface	4				10		k = 0.635 A4 = -3.358846 6th surface	e-05			
A4 =	0.000 = 2.06606e–04 . surface							k = 0.000 A4 = 1.78338e- 14th surface	-04			
A4 =	0.000 = -1.79135e-0 . surface	4				15		k = -0.579 A4 = -1.630806 15th surface	e-07			
A4 =	0.000 = -1.13764e-0 . surface	4				20		k = 0.000 A4 = 7.02281e- 16th surface	-08			
	0.000 = -6.19905e-0			5		_		k = 0.000 A4 = -2.61423e 17th surface	e-04			
	V	arious da	ta.			_ 25		k = 0.000				
NA Magnii	fication			0.20 -2.00				A4 = -6.188296 18th surface	≥-04			
Focal l	ength			6.48								
	height (mm) 1) (in air)			4.92 2.35				k = 0.000 A4 = 4.05381e	-10			
	otal length (mn	n) (in air)		38.99		30		19th surface				
	Ex	cample :	32			-		k = 0.000 A4 = -6.673666 20th surface	e-10			
						35 -		k = 0.000 A4 = 3.21970e- 21th surface	-10			
		Unit mm				_		k = 0.000				
	S	urface dat	ta			_		A4 = 2.90162e	-04, A6 =	-7.28026e-0	06	
Surface no.	r	d	nd	\mathbf{v} d	θgf	40			Various	data		
1*	18.031	1.98	1.84666	23.77	0.620		N	ĪΑ			0.23	1
2* 3*	33.383 14.122	0.30 2.63	1.49700	81.61	0.538			Magnification ocal length			-2.00 10.51	
4	112.900	0.10						mage height (mm	1)		4.92	
5 6*	10.797 43.886	2.81 0.22	1.49700	81.61	0.538	45	fl	b (mm) (in air)		:	2.83	;
7	23.680	2.64	1.61800	63.33	0.544			ens total length (iiim) (in a	117)	44.85	
8	-13.093	0.70	1.72047	34.71	0.583							
9	24.412	0.49										
10(Stop) 11	∞ 21.319	-0.33 0.72	1.90366	31.32	0.595	50			Exampl	e 33		
12	5.225	2.41	1.61800	63.33	0.544	50						
13	10.578	0.10										
14*	7.000	3.27	1.49700	81.61	0.538							
15* 16*	8.979 11.132	9.72 4.18	1.58364	30.30	0.599				Unit n	ım		
17*	-33.189	2.46	1.50504	50.50	V.J33	55			Surface	data		
18*	-6.616	0.73	1.49700	81.61	0.538	33						
19*	19.087	5.41	1 500 50	55.00	0.555		Surface no.	r	d	nd	vd	θ gf
20* 21*	-10.000 -8.861	1.47 2.27	1.53368	55.90	0.563		1*	20.173	2.85	1.84666	23.77	0.62
22	−8.801 ∞	0.38	1.51640	65.06	0.535		2*	20.173 44.670	0.10	1.0+000	43.11	0.02
23	œ	0.31				60	3	22.987	0.70	1.65412	39.68	0.57
Image plane	∞					60	4	13,553	0.10			

0.599		-
0.538	55	_
0.563		S
0.535		
	60	

55			Surface	data		
	Surface no.	r	d	nd	νd	$\theta g f$
	1*	20.173	2.85	1.84666	23.77	0.620
	2*	44.670	0.10			
60	3	22.987	0.70	1.65412	39.68	0.574
60	4	13.553	0.10			
	5*	11.056	5.41	1.49700	81.61	0.538
	6	-117.884	0.10			
	7	15.197	3.48	1.49700	81.61	0.538
	8*	-137.586	0.10			
	9	40.695	3.13	1.61800	63.33	0.544
65	10	-15.237	0.70	1.72047	34.71	0.583
	11	13.540	0.95			

166 Example 34

						_						
2(Stop) 3	∞ 21.539	-0.41	1 00266	21 22	0.505	5			Unit mm			
4	21.538 6.309	0.70 2.36	1.90366 1.61800	31.32 63.33	0.595 0.544	•						
5	11.008	0.10	1.01000	05.55	0.0	-		2	Surface da	ta		
6*	6.948	3.38	1.49700	81.61	0.538		Surface no.	r	d	nd	νd	θ gf
7*	-55.578	5.87	1 40700	01.61	0.520	_	Surface no.			nd	,,,	V _S 1
8* 9*	-6.796 18.459	0.70 2.11	1.49700	81.61	0.538	10	1	30.333	3.43	1.84666	23.77	0.620
)*	7.634	3.91	1.58364	30.30	0.599	10	2*	-17.121	0.96	4.500.64	20.20	0.500
1*	-13.003	1.75					3* 4*	-13.803 13.612	0.88 0.11	1.58364	30.30	0.599
2*	-6.810	0.70	1.49700	81.61	0.538		5*	11.200	3.75	1.49700	81.61	0.538
3*	24.381	4.54	1.51.640	65.06	0.525		6	-27.595	0.10			
4 5	& &	0.38	1.51640	65.06	0.535		7	15.356	3.57	1.49700	81.61	0.538
nage plane	× ×	0.30				15	8*	-16.003	0.10			
nage plane						_	9	17.504	2.87	1.61800	63.33	0.544
	Asp	herical sur	face data				10 11	-11.810 8.524	0.70 0.97	1.72047	34.71	0.583
						_	12(Stop)	o.324 ∞	0.56			
	1st surface					_	13	-53.831	0.70	1.72047	34.71	0.583
	1 0.000					20	14	6.850	2.02	1.61800	63.33	0.544
	k = 0.000 A4 = -5.735546	. 06					15	23.795	2.48			
	A4 = -3.733346 2nd surface	3-00					16*	16.577	4.50	1.49700	81.61	0.538
	zna sarrace					_	17*	-46.561	1.38	4 40.500		
	k = 0.000						18*	20.918	2.44	1.49700	81.61	0.538
	A4 = -9.151356	e-06					19* 20*	198.692 15.525	2.30 2.93	1.63490	23.88	0.630
	5th surface					25	21*	-50.829	5.23	1.03450	23.00	0.030
							22*	-9.522	0.71	1.53368	55.90	0.563
	k = -0.393						23*	17.577	1.58	2100000		
	A4 = -2.440076	e=05					24*	-21.349	0.92	1.53368	55.90	0.563
	8th surface					_	25*	27.363	0.66			
	k = 0.000					30	26	∞	0.38	1.51640	65.06	0.535
	A4 = 6.95514e	-05					27	∞	0.30			
	16th surface						Image plane	∞				
	k = -0.579							Asphe	rical surfa	ce data		
	A4 = -2.220856	e-04				-		24	C			
	17th surface					35		2nd st	iriace			
								k = -3	3.179			
	k = 0.000 A4 = -4.216516	- 04						3rd su	ırface			
	A4 = -4.210316 18th surface	:-04										
	Tom surface					_		$\mathbf{k} = 0$.		0.5		
	k = 0.000					40		A4 = 4th su	7.36835e-	-05		
	A4 = -3.618686	-04				40		4ui su	гласе			
	19th surface					_		$\mathbf{k} = 0$.	000			
									-1.21732	e-04		
	k = 0.000							5th su	rface			
	A4 = -7.752816	e-04										
	20th surface					45		k = -(
	k = 0.000								-1.81623	e-04		
	A4 = -6.027736	. 04						8th su	гласе			
	A4 = -0.027736 21th surface	3-04						k = -6	5 612			
	21th surface					_			3.49560e-	-05		
	k = 0.000					50			urface	-03		
	A4 = -6.83570e	-05				30		10010				
	22th surface							k = -().579			
	-					_		A4 =	1.35029e-	-04		
	k = 0.000								urface			
	A4 = 1.18563e	-09										
	23th surface					55		$\mathbf{k} = 0$.				
	1 0000		-		-	-			2.51766e-	-04		
	k = 0.000 $A4 = -1.142216$	_00 44	_1 28240-	.05				18th s	urface			
	A4 = -1.142216	-09, A0 =	-1.283696-	.05		_		k = 0.	000			
		Various o	data						000 2.91305e-	-04		
						- 60			urface			
1	NA			0.23								
N	Magnification			-1.33				$\mathbf{k} = 0$.	000			
	Focal length			10.24				A4 =	6.43367e-	-05		
	mage height (mm	ι)		4.92				20th s	urface			
f	b (mm) (in air) Lens total length (5.09		65						
				43.88				k = -1	0.63			

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	-0	continue	ed						-continue	ed		
		Unit mm				_			Unit mm			
	21th s	urface				- 5		Asph	erical surfa	ce data		
						- ´		2nd sur	face			
	k = 0.0 $A4 = 2$ $22th s$	2.58930e-	-04					k = -3. 3rd sur				
		-4.199186	e-04			10		k = 0.00 A4 = 4 4th sur	.19783e-05	i		
	$\frac{23 \text{th s}}{k} = 0.0$	000				15		k = 0.00 A4 = - 5th sur	1.40144e-0)4		
	24th s		e-04			_		k = 0.0 A4 = - 8th sur:	1.86929e-0)4		
	k = 0.0 $A4 = 1$ $25th s$	l.57977e-	-04			20		k = -4.	445 .87986e-05	;		
		-4.677836				- 25		k = -0. A4 = 8. 17th su	.24143e-06	i		
NA Manaife		arious dat	ta	0.23		-		k = 0.00 $A4 = 2$ 18 th su	.95157e-05	:		
Magnifi Focal le Image h fb (mm)	ength neight (mm)			-1.33 6.71 4.92 1.21		30		k = -4. A4 = 1. 19th su	.98827e-04			
	tal length (mn	n) (in air)		46.39		-		k = 0.00 A4 = 1. 20th su	.82474e-04			
	Ех	kample :	35			35		k = 0.00 A4 = 21th su	5.85060e-0)5		
		Unit mm				- 40			.89211e-12			
		urface dat	to			-		22th su				
Surface no.	r	d	nd	νd	θgf	-		k = 0.00 $A4 = -$ $23th su$	1.93685e-0)4		
1 2*	31.851 -16.956	3.46 0.92	1.84666	23.77	0.620	45		k = 0.00 $A4 = -$	00 5.50486e-0)4		
3* 4*	-14.469 13.498	0.79	1.58364	30.30	0.599		-		Various dat	a		
5* 6 7	11.902 -24.185 15.502	3.99 0.10 3.62	1.49700 1.49700	81.61 81.61	0.538	50	NA Magn	ification			0.23 -1.33	
8* 9	-16.536 17.521 -12.188	0.10 2.82 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583	50	Focal Image	length height(mm) n) (in air)			-1.33 6.94 4.92 1.39	
11 12(Stop) 13	8.905 ∞ -25.439	1.29 0.87 0.70	1.72047	34.71	0.583	55		total length(m	m) (in air)		46.76	
14 15 16* 17*	7.636 40.459 12.506 -25.450	2.05 3.76 4.08 4.84	1.61800 1.49700	63.33 81.61	0.544			Е	Example (36		
18* 19* 20*	16.621 -45.468	2.91 5.15	1.63490	23.88	0.630	60			TT 1:			
21.15	-11.176 28.944	0.70 1.68 0.70	1.53368 1.53368	55.90 55.90	0.563 0.563				Unit mm Surface dat	a		
21*	-16 379		1.0000	22.20	0.505				-armee dat			
21* 22* 23* 24 25	-16.379 19.903 ∞ ∞	0.84 0.38 0.30	1.51640	65.06	0.535		Surface no.	r	d	nd	νd	θ gf

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	-	continue	ed					-	continu	ea		
		Unit mm				_			Unit mm			
3*	-14.367	0.70	1.58364	30.30	0.599	- 5		(mm) (in air)			3.55	
4* 5*	13.393	0.36	1 40700	91 61	0.529	3	Le	ns total length(mr	n) (in air)		47.77	
6	12.942 -22.078	3.94 0.10	1.49700	81.61	0.538							
7	13.900	3.96	1.49700	81.61	0.538							
8*	-17.689	0.30						E	xample	37		
9	17.537	2.78	1.61800	63.33	0.544	10			•			
0 1	-13.673 9.167	0.70 1.30	1.72047	34.71	0.583	10						
2(Stop)	∞	0.93										
3	-18.729	0.70	1.72047	34.71	0.583				Unit mm			
4	7.839	2.04	1.61800	63.33	0.544				7 C 1			
5 6*	43.718 11.769	4.70 4.45	1.49700	81.61	0.538				Surface da	ta		
7 *	-21.669	4.43	1.49700	81.01	0.556	15	Surface no.	r	d	nd	νd	θ gf
8*	14.851	2.87	1.63490	23.88	0.630							
9*	-125.046	5.08					1	35.018	3.51	1.84666	23.77	0.620
0*	-7.502	0.70	1.53368	55.90	0.563		2* 3*	-16.160 -14.606	0.79 0.70	1 59264	30.30	0.599
1 * 2	12.654 ∞	2.99 0.38	1.51640	65.06	0.535		4*	12.706	0.70	1.58364	30.30	0.399
3	∞ ∞	0.30	1.31040	03.00	0.555	20	5*	10.540	4.39	1.49700	81.61	0.538
nage plane	∞						6	-25.094	0.10			
						_	7	18.037	3.48	1.49700	81.61	0.538
	Asphe	erical surfa	ice data				8 * 9	-15.488	0.30	1.61800	62.22	0.544
	21	c				_	10	17.578 -11.708	2.82 0.71	1.72047	63.33 34.71	0.544
	2nd sur	race				— 25	11	8.764	1.28	1.72047	34.71	0.565
	k = -2.6	532					12(Stop)	∞	0.86			
	3rd surf						13	-50.664	1.06	1.72047	34.71	0.583
						_	14	6.843	3.93	1.61800	63.33	0.544
	k = 0.00	00					15	22.209	3.20			
	A4 = 2.5	85023e-05	5			•	16*	18.515	3.84	1.49700	81.61	0.538
	4th surf	ace				30	17* 18*	-19.905 61.312	0.36 2.44	1.49700	81.61	0.538
							19*	-138.576	1.98	1.49700	61.01	0.550
	k = 0.00						20*	16.819	3.04	1.63490	23.88	0.630
	A4 = -1 5th surf	.67992e=()4				21*	-44.496	5.21			
	<u> </u>	ace				_	22*	-6.697	0.83	1.53368	55.90	0.563
	k = -0.2	266				35	23*	12.737	1.65	1.52260	55.00	0.567
		.93461e-0	04				24 25	91.429 100.508	0.70 0.51	1.53368	55.90	0.563
	8th surf						26	∞	0.38	1.51640	65.06	0.535
	-					_	27	∞	0.30			
	k = -4.8						Image plane	∞				
		0.96312e=0	06			40		. 1				
	16th sui	face				_		Asphe	rical surfa	ce data		
	k = -0.5	70						2nd sur	face			
		15323e-05	5									
	17th su							k = -3.2				
	-					- 45		3rd surf	ace			
	k = 0.00					73		k = 0.00	ın.			
		61252e-05	5						48353e-0:	5		
	18th sui	face				_		4th surf				
	k = -1.0	142							_			
		95706e-05				50		k = 0.00		34		
	19th su		,			50		A4 = -1 5th surf	01898e	J 4		
						_		241 5411				
	k = 0.00	00						k = -0.2	286			
		80359e-05	5						.38466e-)4		
	20th sui	face				_		8th surf	ace			
	1- 0.00	NO.				55		k = -5.5	555			
	$k = 0.00$ $\Delta \Delta = \Delta$	ю 18334e-04	1						80018e-0:	5		
	A4 = 4. 21th su		T					16th sur				
	21111 8111					_				_		
	k = 0.00	00						k = -0.5		4		
		2.24974e-0)4			60		A4 = 1.3 17th sur	25353e-04 face	+		
						-		1 / til Stil	iacc			
		Various da	ta					k = 0.00				
						_		44 2	20448e-04	1		
XT A				0.22						+		
NA Mao				0.23						+		
Mag	gnification al length			0.23 -1.33 8.73		65			face	+		

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	-	continue	ed					-	continue	ed		
		Unit mm				•			Unit mm			
	19th su	rface				- 5		Asphe	erical surfa	ce data		
						-		2nd sur	face			
	k = 0.00 $A4 = 1.$ $20th such$	43266e-04	1			_		k = -2.6 3rd surf				
		56841e-04	1			10		k = 0.00 $A4 = -1$ $4th surf$.47660e-0)5		
	$\frac{21 \text{th su}}{k} = 0.00$ $A4 = 2$		1			15		k = 0.00 $A4 = -1$ $5th surf$	1.00180e-0)4		
	22th su:	rface				_		k = -0.2 $A4 = -1$ $8th surf$	1.23946e-0)4		
	k = 0.00 $A4 = 2.$ $23th succession$	73060e-04	1			20		k = -4.4	194 28557e-05	;		
	k = 0.00 $A4 = -9$)() 9.16648e=(04			- 25		k = -0.5	579 96708e-04	ı		
N	ÍΑ	Various da	ta	0.23		_ 25 _		k = 0.00 A4 = 1. 18th sur	64979e-04	ļ		
Fo In	fagnification ocal length nage height(mm) o(mm) (in air)			-1.33 8.25 4.92 1.06		30		k = 0.00 A4 = 2. 19th sur	23578e-04	ļ.		
L	ens total length(mi	n) (in air)		48.56		•		k = 0.00 A4 = 1. 20th sur	34637e-04	ļ		
	E	xample	38			35		k = -3.5 $A4 = 3.$ $21th sun$	22843e-04	ļ		
		Unit mm				- 40		k = 0.00 A4 = 3. 22th sur	61442e-04	ļ		
		Surface da	ta					k = 0.00				
Surface no.	r	d	nd	\mathbf{v} d	$\theta g f$			A4 = -5 $23th su$	5.63782e=0 rface)4		
1	49.656	3.69	1.84666	23.77	0.620	45		k = 0.00				
2* 3*	-17.011 -16.943	0.30	1.58364	30.30	0.599				1.15728e=0			
4* 5*	15.231 12.554	0.30 5.18	1.49700	81.61	0.538				Various dat	ta		
6 7	-22.778 19.262	0.10 4.38	1.49700	81.61	0.538	50	NA	nification			0.23 -1.33	
8*	-14.960	0.30	1.42700	01.01	0.556	30		l length			9.31	
9	23.487	2.73	1.61800	63.33	0.544			e height(mm)			4.92	
0 1	-17.685 9.522	0.70 1. 44	1.72047	34.71	0.583			m) (in air) total length(mr	m) (in aim)		3.49 53.44	
2(Stop)	oo 0.322	0.85					Lens	totai iengin(iii	п) (ш ап)		33.44	
3	-38.910	0.70	1.72047	34.71	0.583	55						
4	6.507	2.02	1.61800	63.33	0.544			_		3.0		
5 6*	13.505 14.532	1.43 8.57	1.49700	81.61	0.538			Е	xample (39		
7*	57.509	0.41	1.77/00	01.01	0.000							
8*	13.489	4.45	1.49700	81.61	0.538							
9* 0*	-401.830	1.74	1 (2 (22	22.00	0.630	60						
0* 1*	15.589 -58.753	3.51 4.86	1.63490	23.88	0.630	- 0			Unit mm			
1** 2*	-38.733 -7.832	1.58	1.53368	55.90	0.563		_		Surface dat	a		
3*	15.936	2.94	1.00000									
4	∞	0.38	1.51640	65.06	0.535		Surface no.	r	d	nd	vd	θgf
5	& &	0.30				65	1*	15.101	3.29	1.49700	81.61	0.538
mage plane												

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		Unit mm				_							
3	-675.554	0.86	1.50220	54.74	0.551	- 5				Unit mm			
ļ. 5*	13.373 14.021	1.32 5.03	1.49700	81.61	0.538	-							
,	-18.164	0.10	1.42700	01.01	0.556	-			S	urface dat	ta		
	14.881	3.21	1.49700	81.61	0.538		Surface r	10.	r	d	nd	vd	θgf
*	-54.750 50.000	0.32 3.52	1.61800	63.33	0.544	-							
	-18.151	1.71	1.72047	34.71	0.583	10	1* 2*		13.980 -20.000	5.56 0.90	1.49700 1.51633	81.61 64.06	0.538
	-3000.000	0.50					3*		13.407	1.32	1.31033	04.00	0.553
(Stop)	00 47 495	0.37	1.75500	52.22	0.547		4*		13.448	4.59	1.49700	81.61	0.538
	47.485 -30.000	4.43 1.93	1.75500 1.71775	52.32 32.36	0.547 0.593		5		-23.931	0.10			
	6.109	3.62	1.71775	52.50	0.555		6 7*		20.404	3.02	1.49700	81.61	0.53
*	-7.419	4.50	1.49700	81.61	0.538	15	7* 8		-54.118 15.790	0.30 4.48	1.61800	63.33	0.54
*	-8.241	0.90					9		-19.586	0.70	1.72047	34.71	0.58
*	12.630	4.46	1.80610	40.40	0.570		10		16.357	0.91			
*	-59.865 -14.507	3.19 1.72	1.60614	32.96	0.598		11(Stop)		00	0.94			
*	19.347	1.54	1.00014	32.70	0.570		12		14.986	4.50	1.75500	52.32	0.54
	∞	0.38	1.51640	65.06	0.535	20	13 14		-30.000 5.558	1.15 3.03	1.62588	35.70	0.58
	œ	0.31				20	15*		-7.759	4.50	1.49700	81.61	0.53
age plane	∞						16*		-9.446	0.30			
	Acnhe	rical surfa	ce data			_	17*		14.699	4.50	1.80610	40.40	0.57
	2 корис.	iicai suiia	ce data			_	18*		-33.410	2.70	1.522.60	55.00	0.50
	1st surface					2.5	19* 20*		-12.364 20.278	2.02 1.43	1.53368	55.90	0.56
						— 25	21		20.276 ∞	0.38	1.51640	65.06	0.53
	k = 0.000 A4 = 6.55745e - 05						22		∞	0.31			
	2nd surface						Image pl	ane	∞				
									Asphe	rical surfa	ce data		
	k = 0.000 A4 = 1.15283e - 04					30		1st sur	face				
	5th surface					_		181 811	race				
	1- 0.000							k = 0.0		A.C. 1	ECCEE- 07		
	k = -0.990 $A4 = 1.66321e - 0.50$							A4 = 7 2nd su	'.72147e-06	, A0 = -1	.56655e=U/		
	8th surface							Ziid bu	inacc				
						— 35		k = 0.0					
	k = 0.000								.95212e-06				
	A4 = 1.25514e - 04							3rd sur	тасе				
	16th surface					_		k = 0.0	000				
	k = -0.579								.51990e-06				
	A4 = -1.39447e - 0.379	15				40		4th sur	face				
	17th surface							k = -0	280				
						_			.200 -4.12102e-0	5			
	k = 0.000							7th sur					
	A4 = 6.26727e - 05												
	18th surface					45		k = 0.0	100 1.26104e-05				
	k = 0.000							A4 = 9 15th si					
	A4 = -5.34476e - 0	15						154150	arace				
	19th surface							k = -0	.579				
						_			-1.80982e=0	5			
	k = 0.000					50		16th sı	ırtace				
	A4 = -7.96647e - 0	15						k = 0.0	100				
	20th surface					_			i.97386e-05				
	k = 0.000							17th sı	ırface				
	A4 = 6.62595e - 05							k = 0.0	100				
	21th surface					55			-8.07041e=0	5			
	1 0000							18th su					
	k = 0.000 A4 = -6.63922e - 0	5 46	4 528446_06					1 0.0	100				
				,		_		k = 0.0 $A4 = -$:00 -1.42087e=0	4			
		arious dat	ta			– 60		19th su	ırface				
N	JA			0.23		0.0		k = 0.0	00				
N	Magnification (-1.30				A4 = 1	.27864e-04				
	ocal length			11.64				20th st	ırface				
	mage height(mm)			4.92				1- 0-					
	b(mm) (in air)	(in -!-)		2.10		65		k = 0.0		1 16	7 641 22 - 00	:	
L	ens total length(mn	ı) (ın aır)		47.88		0.5		A4 = -	-1.234/3e-C	4, A0 = -	7.64122e-06)	

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	-0	continue	ed					-0	continue	ed		
		Unit mm							Unit mm			
	V	arious da	ta			- 5	23th surface					
fb(mm)	ngth neight(mm)	ı) (in air)		0.23 -1.30 11.19 4.92 1.99 47.51		10	k = 0.000 A4 = 8.84524e 24th surface k = 0.000 A4 = -6.21360					7
						_		V	⁄arious da	ta		
	Ех	kample	41			15	-				0.23 -1.32 5.34 4.75 1.63	
		Unit mm				_	, ,	tal length(mm	ı) (in air)		42.87	
	S	urface da	ta			20						
Surface no.	r	d	nd	νd	$\theta g f$							
1 2 3	25.769 18.855 -40.476	1.00 2.85 5.37	1.78800 1.84666	47.37 23.78	0.556 0.620	25		Ех	kample	42		
4* 5*	-12.747 11.476	0.60 0.10	1.58366	30.23	0.594	_			Unit mm			
6* 7*	8.066 -8.996	3.75 0.10	1.49700	81.61	0.538	-		S	urface da			
8 9	24.048 -8.000	2.60 1.00	1.61800 1.72047	63.33 34.71	0.544 0.583	30	Surface no.	r	d	nd	νd	θgf
10	26.872	1.85	1.72047	54.71	0.505	_						
11(Stop) 12	∞ 9.076	0.30 0.60	1.90366	31.32	0.595		1 2	40.476 -18.855	1.93 1.00	1.84666 1.78800	23.78 47.37	0.62 0.55
13	5.849	1.82	1.53996	59.46	0.544		3	-25.769	5.63			
14	16.303	1.19	1.40700	91 61	0.529		4* 5*	-12.272	1.63	1.58366	30.23	0.59
15 16	10.078 27.029	2.13 0.10	1.49700	81.61	0.538	35	6 *	12.511 8.053	0.10 3.59	1.49700	81.61	0.53
17*	14.378	3.00	1.63491	23.81	0.624		7*	-9.092	0.10			
18*	-11.061	0.10	1 40700	01.61	0.520		8 9	36.029	2.41	1.61800	63.33	0.54
19 20	30.935 5.275	1.06 2.65	1.49700	81.61	0.538		10	-8.000 127.453	1.85 0.79	1.72047	34.71	0.58
21	-8.961	3.00	1.75299	26.43	0.613	40	11(Stop)	œ	0.30			
22	-10.149	5.48				40	12	11.461	0.60	1.90366	31.32	0.59
23*	-7.320	0.60	1.63491	23.81	0.624		13	5.817	1.60	1.53996	59.46	0.54
24* 25	17.259 ∞	1.08 0.38	1.51641	65.06	0.535		14 15	12.210 8.567	0.10 1.27	1.48749	70.23	0.53
26	∞	0.38	1.51071	05.00	0.333		16	13.023	0.57	1.70/72	10.23	0.00
Image plane	∞					15	17	12.975	1.75	1.49700	81.61	0.53
	Ambo	rical surfa	ice data			4 5	18 19*	21.711 13.032	0.10 3.00	1.63491	23.81	0.62
	Aspnet	near suria	oc uata			_	20*	-10.432	0.10	1.03491	23.01	0.02
4th surface						_	21	32.856	1.80	1.49700	81.61	0.53
l- 0.000							22	5.469	3.30	1.04666	22.70	0.00
k = 0.000 A4 = -1.764296	e-04. A6 = 6	.30527e=0	07			50	23 24	-8.726 -9.698	3.00 4.14	1.84666	23.78	0.61
5th surface	,					_	25*	-7.320	0.60	1.63491	23.81	0.62
1 0.000						_	26*	17.259	1.08	1 51 511	65.06	0.55
k = 0.000 A4 = -2.324576 6th surface	e-04, A6 = -0	6.86686e-	-07			<u> </u>	27 28 Image plane	8 8	0.38 0.30	1.51641	65.06	0.53
k = -1.081						55		Ambo	rical surfa	ice data		
A4 = -2.892786 7th surface	e-04, A6 = 1.	34631e-(06			-	4th surface	дарие	vai ottiid	.co data		
k = -0.300 A4 = 4.59425e- 17th surface	-05, A6 = 1.4	9990e-06	5			60	k = 0.000 $A4 = -2.20622$ 5th surface	e-04, A6 = 1.	84877e-(06	_	
k = 0.000 A4 = -2.679156 18th surface	e-04, A6 = -3	3.04912e-	-06, A8 = -1	.25579e-(07	_	k = 0.000 A4 = -2.39829 6th surface	0e-04, A6 = 1.	41106e-0	06		
k = 0.000 A4 = 3.85802e-	-04, A6 = -8.	.69760e-(06, A8 = -2.9	98874e-0	3	65	k = -1.082 $A4 = -2.94477$	'e-04, A6 = 2.	15880e-0	06		

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		Unit mm				_	Unit mm
7th surface						- 5	Aspherical surface data
				-			2nd surface
k = -0.170 A4 = 9.04640e 19th surface	-05, A6 = 1.7	4380e-06	5			_	k = -2.852 3rd surface
k = 0.000 A4 = -1.93247 20th surface	e-04, A6 = -2	2.53963e-	-06, A8 = -5	80800e-0	08	10	k = 0.000 A4 = 3.99545e-06 4th surface
k = 0.000 A4 = 3.92431e	-04, A6 = -6.	94103e-0)6, A8 = 2.82	007e-08		15	k = 0.000 A4 = -1.80111e-04 5th surface
25th surface k = 0.000						-	k = 0.023 A4 = -1.98268e-04 8th surface
A4 = 8.84524e- 26th surface	-04, A6 = -1.	13249e-0	05, A8 = 3.91	153e-07		20	k = -2.944 A4 = 1.69124e-05 16th surface
k = 0.000 A4 = -6.21360	e-04, A6 = 1.	53368e-0	05, A8 = -3.8	9452e-07	7	- 25	k = -0.579 A4 = -6.22198e-05 17th surface
NA		arious dat	ta	0.23			k = 0.000 A4 = 1.32946e-05 18th surface
-	ength neight (mm)			-1.32 5.31 4.75		30	k = -1.194 A4 = 2.27221e-07 19th surface
) (in air) tal length (mn	n) (in air)		1.63 42.87		-	k = 0.000 A4 = 5.73551e-06 20th surface
	Ех	ample -	43			35	k = 0.000 A4 = 2.95534e-06 21th surface
		Unit mm				- 40	k = 0.000 A4 = -1.18942e-06 22th surface
						•	k = 0.000
		urface dat	ta				A4 = 2.62449e-06
Surface no.		urface dat	nd	νd	θgf	_	23th surface
1 2*	r 32.668 -16.839	d 3.43 0.79	nd 1.84666	23.77	0.620	- 45	
1 2* 3* 4*	32.668 -16.839 -14.534 13.753	d 3.43 0.79 0.70 0.35	nd 1.84666 1.58364	23.77 30.30	0.620	- 45 -	$\frac{23\text{th surface}}{\text{k} = 0.000}$
1 2* 3* 4* 5*	r 32.668 -16.839 -14.534 13.753 13.429	d 3.43 0.79 0.70 0.35 3.98	nd 1.84666	23.77	0.620	- 45 -	23th surface $k = 0.000$ $A4 = -2.59746e-06$ Various data
1 2* 3* 4*	32.668 -16.839 -14.534 13.753	d 3.43 0.79 0.70 0.35	nd 1.84666 1.58364	23.77 30.30	0.620	- 45 - 50	
1 2* 3* 4* 5* 6 7 8*	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30	nd 1.84666 1.58364 1.49700 1.49700	23.77 30.30 81.61 81.61	0.620 0.599 0.538 0.538	-	
1 2* 3* 4* 5* 6 7 8* 9	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79	nd 1.84666 1.58364 1.49700 1.49700 1.61800	23.77 30.30 81.61 81.61 63.33	0.620 0.599 0.538 0.538	-	
1 2* 3* 4* 5* 6 7 8* 9	s 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70	nd 1.84666 1.58364 1.49700 1.49700	23.77 30.30 81.61 81.61	0.620 0.599 0.538 0.538	-	
1 2* 3* 4* 5* 6 7 8* 9	s r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03	nd 1.84666 1.58364 1.49700 1.49700 1.61800	23.77 30.30 81.61 81.61 63.33	0.620 0.599 0.538 0.538	-	
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop)	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 \$\infty\$	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047	23.77 30.30 81.61 81.61 63.33 34.71	0.620 0.599 0.538 0.538 0.544 0.583	50	
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop)	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 60 -19.591	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047	23.77 30.30 81.61 81.61 63.33 34.71	0.620 0.599 0.538 0.538 0.544 0.583	-	
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 \$\infty\$	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047	23.77 30.30 81.61 81.61 63.33 34.71	0.620 0.599 0.538 0.538 0.544 0.583	50	
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14	s r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 17.346 -12.239 9.694 \$\infty\$ -19.967 7.666	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70 2.09	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047	23.77 30.30 81.61 81.61 63.33 34.71	0.620 0.599 0.538 0.538 0.544 0.583	50	
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18*	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 -0.666 39.824 13.644 -18.626 18.113	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70 2.09 5.19 5.65 3.78 2.84	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047 1.72047	23.77 30.30 81.61 81.61 63.33 34.71 34.71 63.33	0.620 0.599 0.538 0.538 0.544 0.583	50	
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19*	s r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 ∞ -19.591 7.666 39.824 13.644 -18.626 18.113 -72.883	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70 2.09 5.19 5.65 3.78 2.84 4.98	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047 1.61800 1.49700 1.63490	23.77 30.30 81.61 81.61 63.33 34.71 34.71 63.33 81.61 23.88	0.620 0.599 0.538 0.538 0.544 0.583 0.544 0.583	50	23th surface k = 0.000 A4 = -2.59746e-06 Various data NA 0.23 Magnification -1.33 Focal length 7.78 Image height (mm) 4.92 fb (mm) (in air) 1.35 Lens total length (mm) (in air) 48.97 Example 44
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20*	s r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 -19.591 7.666 39.824 13.644 -18.626 18.113 -72.883 -17.228	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 1.03 1.14 0.70 2.09 5.65 3.78 2.84 4.98 0.70	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047 1.61800 1.49700	23.77 30.30 81.61 81.61 63.33 34.71 34.71 63.33 81.61	0.620 0.599 0.538 0.538 0.544 0.583 0.544 0.583	50	
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21*	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 60 -19.591 7.666 39.824 13.644 -18.626 18.113 -72.883 -17.228	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70 2.09 5.65 3.78 2.84 4.98 0.70 1.78	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.63490 1.53368	23.77 30.30 81.61 81.61 63.33 34.71 34.71 63.33 81.61 23.88 55.90	0.620 0.599 0.538 0.538 0.544 0.583 0.544 0.538 0.630 0.563	50	23th surface k = 0.000 A4 = -2.59746e-06 Various data NA 0.23 Magnification -1.33 Focal length 7.78 Image height (mm) 4.92 fb (mm) (in air) 1.35 Lens total length (mm) (in air) 48.97 Example 44 Unit mm
2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22*	s 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70 2.09 5.19 5.65 3.78 2.84 4.98 0.70 1.78 0.84	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047 1.61800 1.49700 1.63490	23.77 30.30 81.61 81.61 63.33 34.71 34.71 63.33 81.61 23.88	0.620 0.599 0.538 0.538 0.544 0.583 0.544 0.583	50	23th surface k = 0.000 A4 = -2.59746e-06 Various data NA 0.23 Magnification -1.33 Focal length 7.78 Image height (mm) 4.92 fb (mm) (in air) 1.35 Lens total length (mm) (in air) 48.97 Example 44
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22* 23*	r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694 60 -19.591 7.666 39.824 13.644 -18.626 18.113 -72.883 -17.228	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70 2.09 5.65 3.78 2.84 4.98 0.70 1.78	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.63490 1.53368	23.77 30.30 81.61 81.61 63.33 34.71 34.71 63.33 81.61 23.88 55.90	0.620 0.599 0.538 0.538 0.544 0.583 0.544 0.538 0.630 0.563	50	23th surface k = 0.000 A4 = -2.59746e-06 Various data NA 0.23 Magnification -1.33 Focal length 7.78 Image height (mm) 4.92 fb (mm) (in air) 1.35 Lens total length (mm) (in air) 48.97 Example 44 Unit mm
1 2* 3* 4* 5* 6 7 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21*	s 32.668 r 32.668 -16.839 -14.534 13.753 13.429 -19.967 15.031 -17.691 17.346 -12.239 9.694	d 3.43 0.79 0.70 0.35 3.98 0.10 3.74 0.30 2.79 0.70 1.03 1.14 0.70 2.09 5.19 5.65 3.78 4.98 0.70 1.78 4.98 0.84 0.80	nd 1.84666 1.58364 1.49700 1.49700 1.61800 1.72047 1.61800 1.49700 1.63490 1.53368 1.53368	23.77 30.30 81.61 81.61 63.33 34.71 34.71 63.33 81.61 23.88 55.90 55.90	0.620 0.599 0.538 0.538 0.544 0.583 0.544 0.538 0.630 0.563	50	23th surface k = 0.000 A4 = -2.59746e-06 Various data NA

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	-(continu	ed					-0	continue	ed		
		Unit mm	1						Unit mm			
3*	-14.579	0.71	1.58364	30.30	0.599	- ₋		23th s	urface			
4* 5*	16.856 16.777	0.41 3.81	1.49700	81.61	0.538	,						
6	-15.718	0.10						$\mathbf{k} = 0.0$. 06		
7 8*	19.072 -17.469	3.37 0.30	1.49700	81.61	0.538	_		A4 = -	-2.84367e	-00		
9	17.675	2.70	1.61800	63.33	0.544			7	arious dat	а		
10 11	-12.437 8.495	0.70 1.08	1.72047	34.71	0.583	10 _	371					
12(Stop)	0.423	0.82					NA Magnit	fication			0.23 -1.33	
13 14	-14.896 10.195	$0.70 \\ 1.80$	1.72047 1.61800	34.71 63.33	0.583 0.544		Focal l				7.87	
15	27.848	1.85	1.01600	03.33	0.544			height (mm)			4.92	
16*	15.325	5.04	1.49700	81.61	0.538	15	,	n) (in air) otal length (mr	n) (in air)		1.75 49.02	
17* 18*	-10.454 13.414	9.60 2.88	1.63490	23.88	0.630	_	Lens ic	otar tength (iiii	II) (III aII)		49.02	
19*	990.845	4.74	2100 15 5	20.00	0.000							
20*	-11.800	0.70	1.53368	55.90	0.563							
21* 22*	51.656 -22.343	1.21 0.70	1.53368	55.90	0.563	20		Ez	kample -	45		
23*	18.755	1.20										
24 25	∞ ∞	0.38 0.30	1.51640	65.06	0.535							
Image plane	∞	0.50				_			Unit mm			
	Asphe	rical surfa	ace data			25		S	urface dat	a		
	2nd st	ırface				_	Surface no.	r	d	nd	νd	$\theta g f$
	k = -2					_	1 2*	74.956 -14.732	2.98 0.57	1.84666	23.77	0.620
	3rd su	ırface				— 30	3*	-12.899	0.70	1.58364	30.30	0.599
	$\mathbf{k} = 0.0$	000					4* 5*	43.976 33.291	0.34 3.01	1.49700	81.61	0.538
	A4 = - 4th su	-1.41730	e-05				6	-17.492	0.10		61.01	
	401 80	Hace				_	7 8*	15.494 -22.742	3.16 0.30	1.49700	81.61	0.538
	$\mathbf{k} = 0.0$					35	9	16.979	2.57	1.61800	63.33	0.544
	A4 = - 5th su	-1.083316 rface	e-04				10 11	-17.660 7.386	0.70 1.26	1.72047	34.71	0.583
						_	12(Stop)	7.360 ∞	0.85			
	$\mathbf{k} = 0.$	711 -2.05079	- 04				13 14	-15.256	0.76	1.72047	34.71	0.583 0.544
	8th su		6-04			40	15	17.797 48.679	1.70 1.26	1.61800	63.33	0.344
						_ 40	16*	14.757	3.95	1.49700	81.61	0.538
	k = -1		0.6				17* 18*	-9.274 12.062	14.60 2.80	1.63490	23.88	0.630
		6.63327e- urface	-06				19*	97.824	2.82	1.05450	23.00	0.050
	1001 8	штасс				_	20*	-17.861	0.70	1.53368	55.90	0.563
	k = -0					45	21* 22*	237.695 -11.342	1.46 0.70	1.53368	55.90	0.563
		-1.141776 urface	e-04				23*	17.018	1.20	1.55500	55.50	0.505
	17018	urrace				_	24 25	& &	0.38 0.30	1.51640	65.06	0.535
	$\mathbf{k} = 0.0$	000 3.77032e-	-05				Image plane	∞	0.50			
		urface				50		Asphe	rical surfa	ce data		
	$\mathbf{k} = 0$.		0.5			_		2nd sı	ırface			
		-1.06116 urface	e-05					k = -2				
	k = 0.	000				 55		3rd su	rface			
		000 1.38376e-	-05			33		$\mathbf{k} = 0$.				
	20th s	urface				_		A4 = 4th su	1.48176e- rface	-04		
	$\mathbf{k} = 0.$							k = 0.	000			_
		3.62602e- urface	-06			60			2.73952e-	-05		
	k = 0.	000										
	A4 = -	-2.19557	e-06					k = 10 A4 = -).865 -1.412646	e-04		
	22th s	urface				_		8th su				
	$\mathbf{k} = 0.0$		06			65		k = -1		05		
	A4 = 4	4.13364e-	-06					A4 = :	5.97656e-	-05		

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-cont	

	-0	continue	d					-(continue	ed		
		Unit mm				_			Unit mm			
	16th s	urface					21*	246.294	1.46			
	1 .	. 570				- 5	22*	-11.062	0.70	1.53368	55.90	0.563
	k = -0 $A4 = -$).579 -1.45146e	-04				23*	16.891	1.20			
	A4 = - 17th s						24	00	0.38	1.51640	65.06	0.53
						_	25 Image plane	σ σ	0.30			
	k = 0.0					10 -	mage plane	<u> </u>				
	A4 = 3 $18 th s$	5.53442e- urface	05			10		Asphe	rical surfa	ce data		
	k = 0.3	704				_		2nd st	ırface			
	A4 = -	-1.23220e	-05					k = -2	2 471			
	19th s	urface				- 15		K = -2 3rd su				
	k = 0.0	000				15						
		4.74431e-	06					$\mathbf{k} = 0$.				
	20th s								1.72263e-	-04		
						_		4th su	rrace			
	k = 0.0		0.6			20		$\mathbf{k} = 0$.	000			
		1.29150e-	OO						3.64682e-	-05		
	21th s	шисе				-		5th su				
	k = 0.0	000										
		1.11008e-	06					k = 13	3.812			
	22th s	urface				- 25		A4 =	-1.65670	e-04		
						- 23		8th su	ırface			
	k = 0.0	000 2.59060e-	06									
	A4 = 2 $23th s$		06					k = -1				
	23413	tarace				_			8.11125e-	-05		
	k = 0.0	000				30		1 our s	surface			
	A4 = -	-1.53883e	-06			30		k = -(579			
						-			-1.27084	e-04		
	V	arious dat	a			_			urface			
NA				0.23		_		-				
Magnif	fication			-1.33		35		$\mathbf{k} = 0$.				
Focal le	-			7.55					4.62229e- surface	-05		
	height (mm)			4.92 1.75				10018	surrace			
	ı) (in air) otal length (mn	n) (in air)		49.05				$\mathbf{k} = 0$.	914			
2000	am rangur (iii	(111 (411)		.,,,,,		_			-7.545326	e-06		
						40		19th s	urface			
	Ex	kample 4	46					$\mathbf{k} = 0$.				
		1							1.97223e-	-06		
								20th s	urface			
						4 5		k = 0.	000			
		Unit mm							4.00526e-	-07		
						-			urface			
	S	urface dat				-		k = 0.	000			
Surface no.	r	d	nd	\mathbf{v} d	θgf	5 0			000 8.92606e-	-07		
1	71.023	2.80	1.84666	23.77	0.620	- 50			surface	VI		
2*	-14.922	0.95	1.04000	١١.د∡	0.020							
3*	-12.661	0.70	1.58364	30.30	0.599			$\mathbf{k} = 0$.	000			
4*	52.837	0.32						A4 = 1	5.45128e-	-07		
5* 6	34.772 -16.453	2.72 0.10	1.49700	81.61	0.538			23th s	surface			
7	17.240	2.71	1.49700	81.61	0.538	55		-				
8*	-21.457	0.30						k = 0.		07		
9	17.407	2.53	1.61800	63.33	0.544			A4 =	-3.69544	e-U/		
10 11	-17.609 7.015	0.70 1.23	1.72047	34.71	0.583	_		τ	Various da	to		
11 12(Stop)	7.015 ∞	0.75				_			various da	ıa		
13	-16.751	0.77	1.72047	34.71	0.583	60	NA				0.20	
14	18.568	1.71	1.61800	63.33	0.544		Magnif	ication			-1.33	
15	54.564	1.28	1.40700	01.71	0.530		Focal le				7.55	
16* 17*	16.776 -8.639	3.75 15.60	1.49700	81.61	0.538			neight (mm)			4.92	
* 1	12.605	2.73	1.63490	23.88	0.630) (in air)			1.75	
18*						65	Lens to	tal length (mr	n) (in air)		49.05	
18* 19* 20*	175.251	2.76			0.563							

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									Unit mm			
		Unit mm				- 5		21th s	urface			
	5	Surface dat	ta			-		k = 0.0	000			
Surface no.	r	d	nd	νd	θgf	_		A4 = -22th s	-2.72835e- urface	-06		
1	53.186	3.31	1.84666	23.77	0.620	-		k = 0.0	200			
2*	-15.475	0.51				10			2.59014e-0	06		
3*	-15.703	0.70	1.58364	30.30	0.599			23th s	urface			
4* 5*	13.712 13.464	0.34 4.14	1.49700	81.61	0.538							
6	-19.181	0.10	1.15700	01.01	0.550			$\mathbf{k} = 0.0$		06		
7	17.400	3.90	1.49700	81.61	0.538	1.5		A4 = -	-3.73844e-	-00		
3*	-17.175	0.30	1 (1000	(2.22	0.544	15		7	arious data	1		
9	17.131 -20.225	2.69 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583				arrous date	•		
1	9.630	1.97	1.72017	51.71	0.505			NΑ			0.23	
2(Stop)	∞	2.03					N	Magnification			-1.33	
3	-26.870	0.70	1.72047	34.71	0.583	20	F	Focal length			8.00	
4	7.211	2.12	1.61800	63.33	0.544	20	1.	mage height (mm)			4.92	
5 6*	28.975 14.848	4.80 5.21	1.49700	81.61	0.538			b (mm) (in air)			1.75	
7 *	-15.080	3.09	1.49700	61.01	0.556		I	Lens total length (mr	n) (in air)		49.07	
, 8*	17.473	2.77	1.63490	23.88	0.630							
)*	-177.281	4.94										
O*	-18.091	0.70	1.53368	55.90	0.563	25						
1*	24.560	1.58						Ez	ample 4	8		
2* 3*	-15.011 19.931	0.70 1.20	1.53368	55.90	0.563							
4	19.931	0.38	1.51640	65.06	0.535							
5	∞	0.30	1.510-10	05.00	0.555							
nage plane	∞					30			Unit mm			
	Asphe	erical surfa	ce data			-		S	urface data	1		
	2nd s	urface				_	Surface no.	r	d	nd	vd	θgf
	k = -	2.086				35	1 2*	-39350.564 -15.096	2.80 0.36	1.84666	23.77	0.620
		urface					3*	-15.047	0.70	1.58364	30.30	0.599
						_	4*	15.659	0.30			
	$\mathbf{k} = 0$.						5*	14.778	3.69	1.49700	81.61	0.538
		-2.155916 urface	=-05				6 7	-22.190 19.531	0.10 4.09	1.49700	81.61	0.538
	401 80	iiiace				_ 40	, 8*	-14.652	0.30	1.42700	01.01	0.55
	$\mathbf{k} = 0$.	.000					9	17.123	2.28	1.61800	63.33	0.54
	A4 =	-1.472236	-04				10	199.434	0.70	1.72047	34.71	0.583
	5th sı	ırface					11	10.381	4.19			
							12(Stop) 13	∞ –76.959	4.31 0.70	1.72047	34.71	0.583
	k = -		^ .			45	14	8.399	2.01	1.61800	63.33	0.54
		-1.864476 ırface	8-04				15	22.390	3.54			
	<u>8tii 8t</u>	шасс				_	16*	14.258	3.78	1.49700	81.61	0.538
	k = -	1.390					17* 18*	-14.525 14.720	2.72 2.59	1.63490	23.88	0.630
	A4 =	1.40344e-	-06				19*	53.371	4.84	1.05450	25.66	0.050
	16th s	surface				50		-13.285	0.70	1.53368	55.90	0.563
							21*	25.319	1.55			
	k = -		0.5				22*	-14.684	0.89	1.53368	55.90	0.563
		–6.47710e surface	e-05				23* 24	31.963 ∞	1.20 0.38	1.51640	65.06	0.53:
	17013	surace				_	25	∞	0.30	1.51010	05.00	0.55.
	$\mathbf{k} = 0$					55	Image plane	∞				
		1.29548e- surface	-05					Asphe	rical surfac	e data		
	k = -	0.598				_		2nd su	rface			
	A4 =	-1.563006	-06					k = -0	.684			
	19th s	surface				- 60		3rd su				
	$\mathbf{k} = 0$.							k = 0.0	000			
		-1.87807e	e-06						-8.51383e-	-05		
	20th s	surface				_		4th su	rface			
	$\mathbf{k} = 0$.	.000				65		k = 0.0	000			
	A4 =	2.90468e-	-06						-1.17461e	-04		

	-	185 continue	ed					-1	186	ed		
		Unit mm				-			Unit mm			
	5th s	urface				-	16*	9.888	3.32	1.49700	81.61	0.538
	A4 =	0.882 -1.49470 urface	e-04			- 5	17* 18* 19* 20*	-27.891 9.778 18.665 -8.157	2.58 2.40 4.60 0.70	1.63490 1.53368	23.88 55.90	0.630 0.563
	k = -	0.931				_	21* 22*	2626.112 -9.615	1.31 2.09	1.53368	55.90	0.563
	A4 =	1.39588e- surface	-05			10	23* 24	-515.428 ∞	1.20 0.38	1.51640	65.06	0.535
		0.579				_	25 Image plane	∞ ∞	0.30			
		-3.931816 surface	e=05					Asphe	rical surfa	ce data		
		.000 3.73980e- surface	-05			15		$\frac{2 \text{nd surf}}{k} = -0.6$				
		.481 9.25556e- surface	-07			20		3rd surf k = 0.00 A4 = -9)5		
	k = 0		e-06			_		$\frac{4\text{th surfa}}{k} = 0.00$				
		surface				- 25		A4 = -15th surfa	.70494e-0 ace)4		
	k = 0.000 $A4 = 4.07916e-06$ $21th surface$ $k = 0.000$					25 _		k = -1.1 A4 = -1 8th surfa	.69703e-0)4		
	k = 0.000 A4 = -5.47250e-06 22th surface					30		k = -1.0		5		
	k = 0.000 A4 = 4.16590e-06 23th surface				_		$\frac{16\text{th sur}}{k = -0.5}$ $A4 = 8.0$ 17th sur	79 05044e-05	;			
	k = 0 A4 =	.000 6.37036	e-06			35		k = 0.00				
		Various da	ta			_			03489e-05	;		
Foo Ima	egnification cal length age height (mm) (mm) (in air)			0.20 -1.33 7.74 4.92 1.75		40		k = -0.0 $A4 = 3.0$ $19th sur$	31417e-06	5		
Lei	ns total length (m	ım) (in air)		48.87		- 45		k = 0.00 $A4 = -2$ $20th sur$.16071e-0)6		
	E	xample	49					k = 0.00 $A4 = 2$ 21th sur	33119e-06	5		
		Unit mm				5 0		k = 0.00 $A4 = -5$	0 .11799e–()6		
		Surface da	ta			_		22th sur				
Surface no.	r	d	nd	νd	θgf	-		k = 0.00 $A4 = 2.8$	0 87005e-06	5		
1 2*	-759.356 -16.189	2.69 0.67	1.84666	23.77	0.620	55		23th sur				
3* 4*	-15.594 13.189	0.70 0.30	1.58364	30.30	0.599			k = 0.00 $A4 = -7$	0 '.50459e-()6		
5* 6	12.715 -30.208	3.60 0.10	1.49700	81.61	0.538							
7 8*	18.195 -14.458	4.42 0.30	1.49700	81.61	0.538	60			Various dat	a		
9 10 11 12(stop)	23.874 58.560 13.172 ∞	1.96 0.70 5.42 5.58	1.61800 1.72047	63.33 34.71	0.544 0.583			NA Magnification Focal length Image height(mm) fb(mm) (in air)			0.20 -1.33 7.45 4.92 1.76	
13 14 15	224.670 9.058 19.643	0.70 2.04 0.90	1.72047 1.61800	34.71 63.33	0.583 0.544	65		Lens total length(mn	n) (in air)		48.85	

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1							_			Unit mm			
Table Tabl		Ţ	Jnit mm				- 5		22th surface				
Tarche no. T d nd vd 0gf 23th surface		Su	rface da	ta			-						
2*	Surface no.	r	d	nd	νd	θgf	_						
1	1* 2*	-38.622		1.84666	23.77	0.620	10)4, A6 = -	2.60414e-06	5	
Section Sect	3			1.65412	39.68	0.574	-		1	Yani assa shat			
7	•	20.044		1.49700	81.61	0.538	_			arious dai	а		
161,039	6			1.40700	91.61	0.539							
99	8*			1.49700	61.01	0.556	15		-				
1 12,119 0.91 10.03	9												
Case	10 11			1.72047	34./1	0.583		fb((mm) (in air)				
4 7.771 1.92 Lo.1800 6.3.3 0.544 20 5 5 10.588 0.20 10.588 0.20 10.588 0.20 10.588 0.20 10.588 0.20 10.588 0.20 10.588 0.20 1.8970 81.61 0.538 8* 2-23.324 0.71 1.49700 81.61 0.538 9* 6.6065 7.57 15.8964 30.30 0.599 25 12*13.178 0.79 1.53368 55.90 0.563 5.89 0.563 12*13.178 0.79 1.53368 55.90 0.563 5.89 0.563 1.1671 9.70 1.	12(Stop)							Le	ns total length(mn	ı) (in air)		56.63	
Section 10,588 0,20	13						-						
6* 6.409 4.13 1.49700 81.61 0.538				1.61800	63.33	0.544	20						
8*	16*			1.49700	81.61	0.538			Γ-	1	<i>c</i> 1		
9°	17*								E	campie	51		
0° 20,127 3,49 1,83364 30,30 0.599 25 1° -9,164 2.84 2° -13,178 0.79 1,53368 55,90 0.563 3° 11,671 9.70 4				1.49700	81.61	0.538							
1	20*			1.58364	30.30	0.599	25						
11.671 9.70 1.53588 55.50 0.585 55.50 0.585	21*									Unit mm			
Margo plane Margo Margo plane Margo Margo plane Margo Margo plane Margo Marg	22* 23*			1.53368	55.90	0.563	-						
Aspherical surface data	24			1.51640	65.06	0.535	_		S	urface dat	а		
1	25 Imaga plana		0.30					Surface no	o. r	d	nd	νd	$\theta g f$
1st surface	mage plane		aal curfa	aa data			_ 30 _		48.290	4.00	1.84666	23.77	0.620
St surface		Asplien	cai suria	ice data			_				1 65412	20.69	0.574
R = 0.000		1st surface					_				1.05412	33.00	0.574
A4 = 5.94361e-05 2nd surface 2nd surface 8		k = 0.000									1.49700	81.61	0.538
2nd surface							35				1 49700	81 61	0.538
Name		2nd surface					_				1.15,00	01.01	0.000
A4 = 5.27712e-05 Sth surface 40 12(Stop)		1 0.000											0.544
5th surface 40 12(Stop) ∞ −0.09 −0.09 k = −0.816 13 36.337 0.70 1.90366 31.32 0.59 A4 = −7.30838e−06 15 10.913 0.10 0.00 16° 6.511 4.50 1.49700 81.61 0.53 K = 0.000 45 19° 6.211 4.33 1.49700 81.61 0.53 A4 = 1.01191e−04 20° 16.578 3.80 1.58364 30.30 0.59 Ioth surface 20° 16.578 3.80 1.58364 30.30 0.59 A4 = −0.579 22° −9.091 0.70 1.53368 55.90 0.56 A4 = −6.69835e−05 22 −9.091 0.70 1.53368 55.90 0.56 A4 = −5.31017e−05 23° 18.805 10.20 1.51640 65.06 0.53 B4 = 0.000 A4 = −5.11715e−04 44 20° 1.51640 65.06 0.53 A4 = −4.44797e−04 20° 45° 80° 80° 80° 80° 80° 80° 80° <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1.72047</td><td>34.71</td><td>0.583</td></td<>											1.72047	34.71	0.583
13 36.33 0.70 1.90366 31.32 0.59 A4 = -7.30838e-06 15 10.913 0.10 8th surface							40						
15							_ 40						0.595
8th surface 16* 6.511 4.50 1.49700 81.61 0.53 17* -24.120 1.67 18* -4.6412 0.73 1.49700 81.61 0.53 A4 = 1.01191e-04 20* 16.578 3.80 1.58364 30.30 0.59 16th surface 21* -8.549 2.73 22* -9.091 0.70 1.53368 55.90 0.56 A4 = -6.69835e-05 24 \infty 0.38 1.51640 65.06 0.53 17th surface 50 25 \infty 0.30 A4 = -5.31017e-05 25 \infty 0.30 18th surface 1st surface A4 = -5.11715e-04 19th surface 25 2nd surface A4 = -4.64797e-04 20th surface 60 A4 = -2.92520e-04 21th surface 65 k = 0.000 A4 = -2.92520e-04 21th surface 45 81 surface A = 0.000 65 k = 0.000 A = 0.000 0.51 0.53 A = 0.000 0.52 0.53 A = 0.000 0.53 A = 0.000 0.54 0.55 A = 0.000											1.61800	63.33	0.544
17*											1.49700	81.61	0.538
A4 = 1.01191e-04		our surface					_						
16th surface 20* 16.578 3.80 1.58364 30.30 0.59							45				1.497/00	81.61	0.538
11											1.58364	30.30	0.599
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		16th surface					_						
A4 = −6.69835e−05 24 ∞ 0.38 1.51640 65.06 0.53 17th surface 50 25 ∞ 0.30 0.53 k = 0.000 A4 = −5.31017e−05 Aspherical surface data 18th surface 1st surface k = 0.000 A4 = −5.11715e−04 A4 = 5.83731e−05 2nd surface k = 0.000 A4 = 5.27684e−05 2nd surface k = 0.000 A4 = 5.27684e−05 3th surface k = 0.000 A4 = -2.92520e−04 A4 = -8.58617e−06 21th surface 8th surface k = 0.000 k = 0.000		k = -0.579									1.53368	55.90	0.563
$k = 0.000 \\ A4 = -5.31017e-05 \\ 18th surface $ $k = 0.000 \\ A4 = -5.11715e-04 \\ 19th surface $ $k = 0.000 \\ A4 = -4.64797e-04 \\ 20th surface $ $k = 0.000 \\ A4 = -2.92520e-04 \\ 21th surface $ $k = 0.000 \\ A4 = -2.92520e-04 \\ 21th surface $ $k = 0.000 \\ A6 = 0.000 \\ A6 = -0.912 \\ A7 = -0.912 \\ $											1.51640	65.06	0.535
k = 0.000 Aspherical surface data 18th surface		17th surface					_ 50			0.30			
18th surface 1st surface $k = 0.000$ $k = 0.000$ $A4 = -5.11715e - 04$ $A4 = 5.83731e - 05$ 19th surface 2nd surface $k = 0.000$ $k = 0.000$ $A4 = -4.64797e - 04$ $A4 = 5.27684e - 05$ 20th surface 5th surface $k = 0.000$ $k = -0.912$ $A4 = -2.92520e - 04$ $A4 = -8.58617e - 06$ 21th surface 8th surface $k = 0.000$ $k = 0.000$							-	mage pia		rical surfa	ca data		
$ k = 0.000 \\ A4 = -5.11715e - 04 \\ 19th surface $ $ k = 0.000 \\ A4 = -4.64797e - 04 \\ 20th surface $ $ 60 $ $ k = 0.000 \\ A4 = -2.92520e - 04 \\ 21th surface $ $ k = 0.000 $ $ A4 = -2.92520e - 04 \\ 21th surface $ $ k = 0.000 $ $ 65 $ $ k = 0.000 $ $ k = 0.000 \\ A4 = -8.58617e - 06 \\ 8th surface $							-		-	ileai suira	ec data		
$\begin{array}{c} A4 = -5.11715e - 04 \\ 19th \ surface \\ \\ k = 0.000 \\ A4 = -4.64797e - 04 \\ 20th \ surface \\ \\ k = 0.000 \\ A4 = -2.92520e - 04 \\ 21th \ surface \\ \\ k = 0.000 \\ A4 = -0.912 \\ A4 = -8.58617e - 06 \\ 21th \ surface \\ \\ k = 0.000 \\ A6 = -0.912 \\ A6 = -8.58617e - 06 \\ 8th \ surface \\ \\ k = 0.000 \\ A6 = -0.912 \\ A7 = -0.912$		l- 0.000							1st surface				
$ \begin{array}{c} 19 $							33		k = 0.000				
$ k = 0.000 \\ A4 = -4.64797e - 04 \\ 20th surface $ 60 $ k = 0.000 \\ A4 = 5.27684e - 05 \\ 5th surface $ $ k = 0.091 \\ A4 = -2.92520e - 04 \\ 21th surface $ $ k = 0.000 $ $ k = -0.912 \\ A4 = -8.58617e - 06 \\ 8th surface $ $ k = 0.000 $ $ 65 $ $ k = 0.000 $							_						
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		k = 0.000							Zira suriace				
20th surface k = 0.000 A4 = -2.92520e-04 21th surface k = 0.000 65 k = -0.912 A4 = -8.58617e-06 8th surface k = 0.000 65 k = 0.000													
A4 = -2.92520e-04 $21th surface$ $k = 0.000$ $A4 = -8.58617e-06$ $8th surface$ $k = 0.000$ 65 $k = 0.000$							– ⁶⁰						
A4 = -2.92520e-04 21th surface $A4 = -8.58617e-06$ 8th surface $A = -8.58617e-06$ 8th surface $A = -8.58617e-06$									k = -0.912				
k = 0.000 65 $k = 0.000$									A4 = -8.58617e - 0	16			
II 0,000		21th surface					_		8th surface				
		k = 0.000					65		k = 0.000				

	-	continue	ed					-c	ontinue	ed		
		Unit mm				_			Unit mm			
	16th surface					- - 5	21*	-9.569	2.94			
	k = -0.579 A4 = -3.17468e- 17th surface	05				- 3	22* 23* 24	−11.357 14.587 ∞	0.70 11.70 0.38	1.53368 1.51640	55.90 65.06	0.563 0.535
	k = 0.000 A4 = -1.40882e- 18th surface	04				10	Image plane		0.30	1.		
						_		Aspher	ical surfa	ce data		
	k = 0.000 A4 = -7.46576e- 19th surface	04						1st surface k = 0.000				
	k = 0.000 A4 = -6.42486e- 20th surface	04				— ₁₅		A4 = 6.61716e-05 2nd surface				
	k = 0.000 A4 = -2.69039e- 21th surface	04				20		k = 0.000 A4 = 5.97222e-05 5th surface				
	k = 0.000 A4 = 1.54596e-0	4				_		k = -0.834 A4 = -2.83924e-0 8th surface	6			
	22th surface k = 0.000 A4 = 1.25420e-0	4				— 25		k = 0.000 A4 = 1.05701e-04 16th surface				
	23th surface k = 0.000 A4 = -5.64464e-	04, A6 = -	-5.63513e-07					k = -0.579 A4 = -6.90189e-0. 17th surface	5			
	,	Various da	ta			_		k = 0.000				
Fo In fb	Agnification ocal length nage height(mm) o(mm) (in air)			0.20 -1.33 14.41 4.92 10.75		35		A4 = -5.47808e-0 18th surface k = 0.000 A4 = -4.86035e-0				
L	ens total length(mi	n) (in air)		55.55		_		19th surface				
	E	xample	52			40		k = 0.000 $A4 = -5.42665e - 0.000$ 20th surface	4			
		Unit mm				- 45		k = 0.000 $A4 = -3.04526e-0.00$ 21th surface	4			
		Surface da				-						
Surface no.	r	d	nd	νd	θgf	- 50		k = 0.000 A4 = 2.66622e-05 22th surface				
1*	51.478	3.20	1.84666	23.77	0.620	50						
2* 3	-38.560 -19.565	2.65 3.38	1.65412	39.68	0.574			k = 0.000 $A4 = -2.09838e-0$	4			
4 5*	30.186 19.873	0.21 4.50	1.49700	81.61	0.538			23th surface	•			
6	-18.633	0.10				55						
7 8*	10.628 212.692	4.21 0.10	1.49700	81.61	0.538			k = 0.000 $A4 = -6.85269e - 0.000$	4 A6	2 12762e=04	ń	
9	24.897	3.19	1.61800	63.33	0.544			711 - 0.03209C-0	.,.10	/020-00	,	
10 11	-30.693 12.401	0.70 0.90	1.72047	34.71	0.583			V	arious da	ta		
12(stop)	8	0.10	1.00266	21.22	0.505	60		NA			0.17	
13 14	55.667 7.805	0.70 1. 84	1.90366 1.61800	31.32 63.33	0.595 0.544			NA Magnification			-1.40	
15	10.579	0.30						Focal length			15.30	
16* 17*	6.428 -23.103	4.02 1.57	1.49700	81.61	0.538			Image height(mm)			4.92	
18*	-110.480	0.70	1.49700	81.61	0.538			fb(mm) (in air)			12.25	
19*	6.147	6.35	1 50274	20.20		65		Lens total length(mm) (in air)		58.05	
20*	17.957	3.44	1.58364	30.30	0.599							

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									Unit mm			
		Unit mm				- 5		22th surface				
		Surface dat	9			-		k = 0.000				
Surface no.	r	d	nd	νd	θgf	_		A4 = -6.53850e - 23th surface	04			
1* 2*	70.275 -30.659	2.70 2.30	1.84666	23.77	0.620	10		k = 0.000 A4 = -9.34773e-	04, A6 = 6	.44915e-07		
3 4	-17.537 35.866	2.26 0.35	1.65412	39.68	0.574				7.75 ml			
5*	27.673	3.95	1.49700	81.61	0.538				Various dat	a		
6 7	-17.104 9.747	0.10 3.94	1.49700	81.61	0.538			NA			0.17	
8*	162.593	0.10				15		Magnification Focal length			-1.40 15.97	
9 10	24.099 -26.964	3.09 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583			Image height(mm)			4.92	
10	12.683	0.70	1.72047	34.71	0.383			fb(mm) (in air)			13.75	
2(Stop)	∞	0.07						Lens total length(mi	m) (in air)		55.83	
13	64.816	0.70	1.90366	31.32	0.595	20						
14 15	7.829 10.768	1.84 0.10	1.61800	63.33	0.544	20						
16*	6.611	3.23	1.49700	81.61	0.538			т		E 1		
17*	-21.476	1.33						Е	xample	54		
18* 19*	-267.827 6.489	0.70	1.49700	81.61	0.538							
20*	23.224	6.45 3.31	1.58364	30.30	0.599	25						
21*	-9.742	3.29				23			Unit mm			
22*	-7.668	0.70	1.53368	55.90	0.563				Omi mm			
23* 24	185.012 ∞	13.20 0.38	1.51640	65.06	0.535				Surface dat	a		
25	∞	0.30	210 2 0 10	00.00	0,000		Surface no.	r	d	nd	νd	θ gf
lmage plane	8					_ 30						
	Asphe	rical surfa	ce data				1* 2*	51.478 -38.560	3.20 2.65	1.84666	23.77	0.620
	1st surface					-	3	-19.565	3.38	1.65412	39.68	0.574
	15t Stillage					_	4 5*	30.186 19.873	0.21 4.50	1.49700	81.61	0.538
	k = 0.000					35	,	-18.633	0.10	1.49700	61.01	0.556
	A4 = 9.37043e - 0.5	5				33	7	10.628	4.21	1.49700	81.61	0.538
	2nd surface					_	8*	212.692	0.10	1 (1000	(2.22	0.544
	k = 0.000						9 10	24.897 -30.693	3.19 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583
	A4 = 8.05222e - 0.5	5					11	12.401	0.90	11,201,	0 1172	0.000
	5th surface					_ 40	12(Stop)	∞	0.10			
	1 0 415						13 14	55.667 7.805	0.70 1. 84	1.90366 1.61800	31.32 63.33	0.595 0.544
	k = 0.415 A4 = 9.29789e - 0.00	5					15	10.579	0.30	1.01600	03.33	0.344
	8th surface	,					16*	6.428	4.02	1.49700	81.61	0.538
						_	17*	-23.103	1.57	4 40700	04.64	0.500
	k = 0.000					45	18* 19*	-110.480 6.147	0.70 6.35	1.49700	81.61	0.538
	A4 = 1.46231e-04	1					20*	17.957	3.44	1.58364	30.30	0.599
	16th surface					_	21*	-9.569	2.94			
	k = -0.579						22*	-11.357	0.70	1.53368	55.90	0.563
	A4 = -1.60507e - 0)4					23* 24	14.587 ∞	11.70 0.38	1.51640	65.06	0.535
	17th surface					50		∞	0.30	1.51010	03.00	0.555
	k = 0.000						Image plane	8				
	A4 = 1.24501e - 04	1						Asph	erical surfa	ce data		
	18th surface					_		1st surface				
	k = 0.000					55						
	A4 = -1.08756e-0	04						k = 0.000 A4 = 6.61716e-0	5			
	19th surface					_		2nd surface				
	k = 0.000							1 0.000				
	A4 = -6.99654e - 6)4						k = 0.000 A4 = 5.97222e-0	5			
	20th surface					_ 60		5th surface				
	k = 0.000							k = -0.834				
	A4 = -3.08028e - 6)4						A4 = -0.834 A4 = -2.83924e	06			
	21th surface					_		8th surface				
	k = 0.000					65		k = 0.000				
	A4 = -1.14935e - 0.000)4				0.5		A4 = 1.05701e - 0	4			
								11. 1.05/010-0	•			

National Common		-	continue	ed					-0	continue	ed		
			Unit mm				_			Unit mm			
\$\frac{k - 0.0070}{17th surface}		16th surface					- - 5	21*	-8.795	0.39			
Response		A4 = -6.90189e - 6.90189e	05				_	22 23* 24	−11.302 23.373 ∞	2.00 2.15 0.38			0.563 0.535
A		$A4 = -5.47808e^{-6}$	05				10	Image plane		rical surfa	ice data		
Ad = -8,86035-0-4		1r = 0.000					_			icai suria	ec data		
A		$A4 = -4.86035e^{-6}$	04										
R		$A4 = -5.42665e^{-6}$	04				15		A4 = 9.25518e-06 2nd surface				
K = 0.000		A4 = -3.04526e - 6	04				20		A4 = 8.47403e - 06				
K = 0.000		k = 0.000 A4 = 2.66622e-03	5				_		A4 = 2.89370e - 06				
R		k = 0.000 A4 = -2.09838e-0	04				— 25		A4 = 6.07603e - 05				
NA		k = 0.000	04, A6 = -	2.12762e-06	5		30		A4 = 2.14569e - 05	, A6 = 8.5	56596e-07		
NA Magnification		7	Various dat	а			_		k = 0.000				
Example 55	M Fe In	fagnification ocal length nage height(mm)			-1.40 15.30 4.92		35		17th surface	5			
Example 55 Example 55 A4 = $-5.24617e-05$ 19th surface A4 = $-5.24617e-05$ 19th surface A4 = $-5.24617e-05$ 19th surface A4 = $-1.13335e-06$ 20th surface 20th surface A4 = $-1.13335e-06$ 20th surface A4 = $-1.1208e-05$ 21th surface A4 = $-1.11.014$ 0.10 A4 = $-1.0108e-05$ 23th surface 23th surface A4 = $-1.0108e-05$ 24th surface A4 =			n) (in air)				_						
Surface no. r d nd vd 0gf		E	xample :	55			40		A4 = -5.24617e - 0	5			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			** 1				- 45		A4 = -1.13335e - 0	6			
Surface no. r d nd vd θgf 1* 25.913 2.07 1.84666 23.77 0.620 2* 31.151 0.30 3* 17.097 6.09 1.49700 81.61 0.538 4 -111.014 0.10 5 16.382 3.66 1.49700 81.61 0.538 6* 76.965 0.10 7 12.471 5.23 1.61800 63.33 0.544 8 -19.985 0.70 1.72047 34.71 0.583 9 10.437 1.53 10(Stop)							-		20th surface				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Surface no.				vd	θgf	_		A4 = 1.01208e - 05				
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				1.84666	23.77	0.620	- 50		Z1 m surface				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				1.49700	81.61	0.538				5			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	4	-111.014	0.10							J			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				1.49/00	01.01	0.558	55						
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$										5 AC	6.06437 01		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	9			1./204/	J4./1	0.565			A4 = -2.94354e-0	э, Ab = -	v.8042/e-06)	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				1 00266	31 22	0.505			V	arious da	ta		
13 7.466 0.10 60 NA 0.23 14* 5.529 3.20 1.49700 81.61 0.538 Magnification -1.10 15 -250.000 0.93 Focal length 12.36 16* -31.020 1.06 1.49700 81.61 0.538 Image height(mm) 4.92 17* 6.332 2.81 fb(mm) (in air) 2.72 18* 13.296 4.02 1.58364 30.30 0.599 65 Lens total length(mm) (in air) 44.83	12	5.760					C C						
15 -250.000 0.93 16* -31.020 1.06 1.49700 81.61 0.538 17* 6.332 2.81 18* 13.296 4.02 1.58364 30.30 0.599 fb(mm) (in air) 2.72 19* -8.640 0.80 65 Lens total length(mm) (in air) 44.83	13	7.466	0.10				60						
16* -31.020 1.06 1.49700 81.61 0.538 Image height(mm) 4.92 17* 6.332 2.81 Image height(mm) 4.92 18* 13.296 4.02 1.58364 30.30 0.599 fb(mm) (in air) 2.72 19* -8.640 0.80 65 Lens total length(mm) (in air) 44.83	14* 15			1.49/00	01.01	0.538			•				
17* 0.332 2.81 18* 13.296 4.02 1.58364 30.30 0.599 fb(mm) (in air) 2.72 19* -8.640 0.80 65 Lens total length(mm) (in air) 44.83	16*	-31.020	1.06	1.49700	81.61	0.538							
19* -8.640 0.80 65 Lens total length(mm) (in air) 44.83				1.58364	30.30	0.599							
20* -7.506 4.48 1.53368 55.90 0.563	19*	-8.640	0.80				65) (in air)		44.83	
	20*	-7.506	4.48	1.53368	55.90	0.563							

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Surface no.		Unit r				•		244 6				
C			IIII			5		24th surface				
C		Surface	data.			•		k = 0.000				
Surface no.	r	d	nd	vd	θgf	•		A4 = -3.30547e- 25th surface	-04			
1 2	22.916 44.302	1.51 0.00	1.60999 1001.00000	27.48 -3.45	0.620 0.296	10		k = 0.000 A4 = -3.69284e-	-04 A6 = -	_2 84789e_06		
3	44.303	0.20	1.63762	34.21	0.594			714 = -3.032040-	04,710 =	-2.047050-00		
4 5*	44.214	0.75 4.50	1 40700	01 61	0.529				Various da	ata		
5** 6	11.892 -75.023	4.50 0.10	1.49700	81.61	0.538			NT A			0.20	
7	16.979	2.78	1.49700	81.61	0.538			NA Magnification			0.20 -1.56	
8*	35.199	0.71				15		Focal length			7.72	
9	19.063	2.75	1.61800	63.33	0.544			Image height(mm)			4.92	
10 11	-18.581 33.626	0.77 1.26	1.72047	34.71	0.583			fb(mm) (in air)			1.76	
12(Stop)	∞	0.30						Lens total length(m	m) (in air)		44.95	
13	29.197	0.83	1.90366	31.32	0.595							
14	5.383	1.47	1.61800	63.33	0.544	20						
15	9.288	0.91	1 40700	01.61	0.530							
16* 17*	6.872 12.602	3.01 1.91	1.49700	81.61	0.538			E	Example	57		
18*	-9.053	3.06	1.49700	81.61	0.538				-			
19*	-10.553	0.91										
20*	12.072	3.90	1.58364	30.30	0.599	25						
21*	-24.825	1.94	1 40700	01.61	0.530				Unit mn	1		
22* 23*	-19.526 11.127	1.01 7.48	1.49700	81.61	0.538							
24*	-59.537	1.12	1.53368	55.90	0.563				Surface da	ata		
25*	19.034	1.10					Surface no.	r	d	nd	vd	$\theta g f$
26	∞	0.38	1.51640	65.06	0.535	30		1	u	nd	vu	Ogi
27 Image plane	∞ ∞	0.41					1*	14.849	2.81	1.84666	23.77	0.620
mage plane							2*	24.251	1.16	1 40700	01.61	0.530
	Asj	herical su	urface data				3* 4	11.029 -159.692	2.65 0.10	1.49700	81.61	0.538
	5.1 6					•	5	24.766	1.11	1.60999	27.48	0.620
	5th surface					- 35	6	25.004	0.00	1001.00000	-3.45	0.296
	k = -0.513						7	25.005	0.20	1.63762	34.21	0.594
	A4 = -1.39397	e-05					8 9	24.343 16.634	0.11 2.86	1.61800	63.33	0.544
	8th surface					_	10	-14.550	0.72	1.72047	34.71	0.583
	k = 0.000						11	28.345	0.47			
	A4 = 7.69283e	-05				40	12(Stop)	∞	-0.05			
	16th surface	0.5					13	28.631	0.72	1.90366	31.32	0.595
						_	14 15	6.286 14.078	1.64 5.35	1.61800	63.33	0.544
	k = -0.579						16*	7.582	3.02	1.49700	81.61	0.538
	A4 = -1.27245 17th surface	e-04					17*	14.928	8.00			
	17th surface					- 45	18*	15.671	3.78	1.58364	30.30	0.599
	k = 0.000					43	19* 20*	-20.144 -10.482	1.79 0.70	1.49700	81.61	0.538
	A4 = -2.00147	e-04					21*	8.846	3.50	1.49700	61.01	0.556
	18th surface					_	22*	13.317	2.28	1.53368	55.90	0.563
	k = 0.000						23*	9.855	2.70			
	A4 = -1.96482	e-04				50	24	œ	0.38	1.51640	65.06	0.535
	19th surface					50 -	25 Image plane	& &	0.30			
	k = 0.000											
	A4 = -5.46173	e-07						Asph	erical surf	ace data		
	20th surface	• • •						1				
						-		1st surface				
	k = 0.000	- 05				55		k = 0.000				
	A4 = -4.97701 21th surface	e-05						A4 = 1.89575e-0)5			
	21th surface					-		2nd surface				
	k = 0.000							k = 0.000				
	A4 = 5.00869e	-05						A4 = 2.05342e - 0)5			
	22th surface					- 60		3rd surface				
	k = 0.000							1 100:				
	A4 = -1.31586	e-04						k = -1.001 A4 = -2.79051e	05			
	23th surface							A4 = -2.79031e- 16th surface	-03			
						_						
	k = 0.000					65		k = -0.579				
	A4 = -1.81687	e-04						A4 = -9.97074e	-05			

		197							198)		
		-continu	ed						-contin	ued		
	Unit mm 17th surface								Unit m	m		
	17th curface						25*	24.022	3.30			
						5	26	φ σ	0.38	1.51640	65.06	0.535
	k = 0.000 $A4 = 4.56155e - 0$)5					27 Image plane	∞ ∞	0.31			
	18th surface						- Intage praise					
	k = 0.000							Asp	herical sur	face data		
	A4 = -1.55616e	-04				10		1st surface				
	19th surface							k = 0.000				
	k = 0.000							A4 = 1.21996e-	-05			
	A4 = -9.53455e-	-05						2nd surface				
	20th surface					15		k = 0.000 A4 = 2.73727e	0.5			
	k = 0.000							A4 = 2.737276 5th surface	-03			
	A4 = 6.03104e - 0 21th surface	05						k = -0.165				
	21010011000							A4 = -1.197106	e-05			
	k = 0.000 $A4 = 5.76196e - 0$	15				20		8th surface				
	22th surface	,3						k = 0.000				
	1 0.000							A4 = 3.40041e- 16th surface	-05			
	k = 0.000 $A4 = 5.52326e - 0$)5						Total startace				
	23th surface					25		k = -0.579 A4 = -1.819016	e_05 A6 =	2 18274e=07		
	k = 0.000							17th surface	03,710 -	2.102746 07		
	A4 = -1.67453e	-04, A6 = -	-3.57134e-06					k = 0.000				
		Various da	ata.					A4 = -9.147126	e-05, A6 =	5.79438e-07		
		various da	ıta			30		18th surface				
	NA Magnification			0.20				k = 0.000				
	Magnification Focal length		-	-1.60 8.33				A4 = -2.044646 19th surface	e-04			
	Image height(mm)			4.92								
	fb(mm) (in air) Lens total length(m	m) (in air)	4	3.25 16.16		35		k = 0.000 A4 = 3.63528e	-05			
								24th surface				
								k = 0.000				
	Г	Example	58					A4 = -3.433096 25th surface	e-05			
	1	zampic	56			40						
								k = 0.000 A4 = -4.643966	e-04			
		Unit mn	<u> </u>						Various o			
		Surface da							various (Titta .	0.22	
						45		NA Magnification			0.23 -1.33	
Surface no.	r	d	nd	νd	θgf			Focal length mage height(mm)		9.33 4.92	
1*	23.262	3.28	1.84666	23.77	0.620		f	b(mm) (in air)			3.86	
2* 3	191.812 53.883	1.33 0.50	1.62588	35.70	0.589		I	Lens total length(mm) (in aiı)	54.14	
4	14.902	0.14				50						
5* 6	13.978 -29.978	5.96 0.10	1.49700	81.61	0.538				Example	e 50		
7	15.765	3.37	1.49700	81.61	0.538				vambr	J J J		
8* 9	510.224 32.798	0.10 3.12	1.61800	63.33	0.544							
10	-19.809 12.325	0.50 1.78	1.72047	34.71	0.583	55	-		TT 1:			
11 12(Stop)	∞	0.78							Unit m			
13 14	-140.812 9.869	0.50 2.61	1.90366 1.61800	31.32 63.33	0.595 0.544				Surface of	lata		
15	113.862	2.42					Surface no.	r	d	nd	\mathbf{v} d	$\theta g f$
16*	11.277 -59.524	3.74 8.10	1.49700	81.61	0.538	60	1*	22.101	3.18	1.84666	23.77	0.620
			1.49700	81.61	0.538		2*	124.650	0.30		23.77	0.020
17* 18*	-3485.657	0.70					3	114.152	0.70	1.62588		
17* 18* 19*	-3485.657 9.598	0.46		27 48	0.620					1.02566	35.70	0.589
17* 18* 19* 20 21	-3485.657 9.598 9.139 -16.931	0.46 5.57 0.00	1.60999 1001.00000	27.48 -3.45	0.620 0.296		4 5*	16.412 13.305	0.30 5.99	1.49700	35.70 81.61	0.589 0.538
17* 18* 19* 20	-3485.657 9.598 9.139	0.46 5.57	1.60999			65	4	16.412	0.30			

.99	200
ntinued	-continued

		Unit	mm						Unit mm	1		
9 10 11 12(Stop)	40.293 −16.251 16.421 ∞	3.15 0.70 1.03 0.57	1.61800 1.72047	63.33 34.71	0.544 0.583	5	i	Image height(mm) fb(mm) (in air) Lens total length(m	m) (in air)		4.92 3.74 55.07	
13 14 15 16* 17 18 19* 20*	-40.907 9.293 -40.883 12.708 27.809 27.809 27.322 28.448	0.57 0.70 3.10 1.32 2.72 0.00 0.20 6.28 1.49	1.90366 1.61800 1.60999 1001.00000 1.63762 1.49700	31.32 63.33 27.48 -3.45 34.21 81.61	0.595 0.544 0.620 0.296 0.594	10			Example		3.01	
21* 22*	12.258 10.768	7.34 3.89	1.58364	30.30	0.599	15			Unit mm	1		
23* 24*	-26.410 -9.722	3.22 0.95	1.53368	55.90	0.563				Surface da	ıta		
25* 26	10.802 ∞	3.19 0.38	1.51640	65.06	0.535		Surface no.	r	d	nd	vd	θgf
27 Image plane	∞ ∞	0.30				20	1* 2*	30.853 -228.348	3.59 0.30	1.84666	23.77	0.620
	As	pherical s	urface data			•	3 4	-228.348 34.422 14.782	0.30 0.70 0.30	1.62588	35.70	0.589
	1st surface					-	5* 6	12.104 -35.889	6.41 0.30	1.49700	81.61	0.538
	k = 0.000	10.05				25	7 8	-49.464 -49.078	0.20 0.00	1.63762 1001.00000	34.21 -3.45	0.594 0.296
	A4 = 1.8166 $2nd surface$	4e-05				-	9	-49.077 -49.077 -60.906	0.70 0.30	1.60999	27.48	0.620
	k = 0.000 A4 = 3.1786 5th surface	7e-05					11 12 13	16.056 -51.065 11.329	4.14 0.70 1.50	1.61800 1.72047	63.33 34.71	0.544 0.583
	k = -0.472 $A4 = -1.546$ 8th surface	552e-05				30	14(Stop) 15 16 17	∞ 29.773 8.337 36.482	-0.25 0.70 3.21 1.31	1.90366 1.61800	31.32 63.33	0.595 0.544
	k = 0.000 $A4 = 2.7094$					35	18* 19* 20*	10.000 108.943 -760.614	3.43 5.30 0.70	1.49700 1.49700	81.61 81.61	0.538 0.538
	$\frac{16\text{th surface}}{k = -0.579}$		1 20042 - 06			-	21* 22* 23* 24*	12.153 10.932 -46.469 -10.332	8.57 4.26 4.54 0.75	1.58364 1.53368	30.30 55.90	0.599 0.563
	A4 = 3.3772 19th surface	,	5 = 1.28843e-06				25* 26	15.919 ∞	2.85 0.38	1.51640	65.06	0.535
	k = 0.000 A4 = 7.6413 20th surface		6 = 1.59199e-06			40	27 Image plane	& &	0.30			
	k = 0.000					_			erical surfa	ace data		
	$A4 = 2.3857$ $\underline{21 \text{th surface}}$ $k = 0.000$					4 5		1st surface k = 0.000 A4 = 9.77276e-0	6			
	A4 = -5.415 $22 th surface$ $k = 0.000$					- 50		2nd surface k = 0.000 A4 = 1.67764e-0	5			
	A4 = -9.209 23th surface k = 0.000 A4 = 1.4876					_		5th surface k = -0.659 A4 = 1.08105e-0 18th surface	5			
	24th surface k = 0.000 A4 = 2.3079 25th surface	8e-04				- 55		k = -0.579 A4 = 5.63637e-0 19th surface	6, A6 = 5.	19107e-07		
	k = 0.000 $A4 = -1.658$					- 60		k = 0.000 A4 = 2.26706e-0 20th surface	6, A6 = 6.	14099e-07		
N ₂	۸	Various	s data	0.23		•		k = 0.000 A4 = -3.93066e- 21th surface	06			
M	agnification cal length			-1.33 10.42		65		k = 0.000 A4 = 1.90962e-0	6			

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-continued		

		ontinue	-u			_	-continued	
		Unit mm					Unit mm	
22th s	surface		-			 - 5	3rd surface	
	.000 -3.81502e-0. surface	5				_	$\begin{array}{l} k = -0.448 \\ A4 = 2.69179 e{-}05, A6 = 2.59561 e{-}07, A8 = 1.81093 e{-}09 \\ 4 th \; surface \end{array}$	
	.000 2.47354e-06 surface					10	k = -2.729 A4 = 2.62358e-05, A6 = 1.66698e-06, A8 = -5.24204e-09 5th surface	
	.000 7.91457e–06, surface	, A6 = 1.4	-4833e-06				k = -2409.520 A4 = -5.88015e-06, A6 = -5.65544e-08 6th surface	
k = 0. A4 =	.000 -1.11135e-0	5, A6 = -	2.19459e-06	j		15	k = 0.023 A4 = 8.78714e-06, A6 = 4.93409e-09	
	V	arious dat	ta			-	7th surface	
fb(mm)	ngth eight(mm)) (in air)		0.23 -1.33 10.62 4.92 3.41 55.07		20	k = -2.423 A4 = -3.77237e-05, A6 = -3.90286e-07, A8 = 6.14283e-09 8th surface k = 1.443 A4 = -3.05033e-05, A6 = 1.08600e-07, A8 = 1.41866e-09	
	Ex	ample	61			25	16th surface k = -1.658 A4 = -1.51099e-05, A6 = 1.28932e-07, A8 = -7.26513e-10 17th surface	
		Unit mm				- 30	k = 0.184 A4 = -2.43950e-05, A6 = -7.20933e-08, A8 = 4.75546e-10 18th surface	
	Si	urface dat	a			_	k = 0.132	
Surface no.	r	d	nd	νd	θgf	- 25	A4 = 6.92244e-06, A6 = 6.19572e-07, A8 = 8.38466e-09 19th surface	
1* 2*	-8.586 -38.013	6.54 0.08	1.53368	55.90	0.563	35	k = -2.887	
3* 4*	23.658 -13.749	5.62 0.05	1.63490	23.88	0.630		A4 = 8.20744e-06, $A6 = -4.23855e-07$, $A8 = 2.80030e-0920th surface$	
5* 6*	483.930 31.754	0.50 0.05	1.58364	30.30	0.599		k = -0.631	
7* 8*	10.006 -22.587	6.19 0.05	1.49700	81.61	0.538	40	A4 = -4.16331e - 06, $A6 = -1.26465e - 07$, $A8 = -9.14719e - 09$)
9	36.901	4.56	1.61800	63.33	0.544		21th surface	
10	-9.647	0.50	1.72047	34.71	0.583		k = -1.191	
11 12(Stam)	15.812 ∞	1.63 0.83					A4 = 5.22955e - 05, $A6 = -4.06789e - 07$, $A8 = -1.05876e - 09$	
12(Stop) 13	-23.387	0.83	1.72047	34.71	0.583	45	22th surface	
14	18.752	3.04	1.61800	63.33	0.544			
15	-24.584	0.12					k = -31.151	
16*	13.844	5.92	1.49700	81.61	0.538		A4 = 7.85252e - 05, $A6 = -4.81367e - 07$, $A8 = -3.45006e - 09$,	
17*	-20.251	9.46					A10 = 2.89579e - 12	
18*	-10.122	5.91	1.58364	30.30	0.599		23th surface	
19*	-13.868	2.45	1 50264	20.20	0.500	50	k = -0.713	
20* 21*	-9.722 -7.658	7.60 3.02	1.58364	30.30	0.599		K = -0.713 A4 = -4.71492e - 05, $A6 = -4.75038e - 08$, $A8 = -1.74975e - 10$)
22*	-16.164	3.70	1.63490	23.88	0.630		A10 = -7.97360e-12	,
23*	-27.524	0.05	1.05470	25.00	0.050		24th surface	
24*	7.572	5.94	1.53368	55.90	0.563		TOOL TO COLUMN T	
25*	3.912	6.00				55	k = -4.264	
26	œ	0.30	1.51640	65.06	0.535		A4 = -3.18002e - 04, $A6 = 1.39934e - 06$, $A8 = 7.25578e - 09$,	
27	œ	6.28					A10 = -5.39754e - 11	
Image plane	8					_	25th surface	
	Aspher	ical surfa	ce data				k = -1.881	
						60	A4 = -3.56331e-04, A6 = 5.70132e-06, A8 = -5.32334e-08, A10 = 2.10863e-10	
1st surface						_	1115 - 21100000 10	
1st surface k = 0.580							T7 1	
k = 0.580 A4 = -9.120756	e-04, A6 = 5	36263e-0	05, A8 = -3.6	1636e-06	5	_	Various data	
	e-04, A6 = 5	36263e-0	05, A8 = -3.6	51636e-06	<u> </u>	- 65	Various data NA 0.60 Magnification -3.57	

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-continue	·

	-(continue	ed					-0	continu	ed		
		Unit mm	l						Unit mm			
T 1	!-1+()			7.93		-	8th surface					
fb(mm)	neight(mm) (in air) tal length(mm	ı) (in air)		12.47 86.77		5	k = 1.450 A4 = -3.05845 16th surface	e-05, A6 = 1.	01828e-0	97, A 8 = 1.52	!990e-09	
	Ел	kample	62			10	k = -1.658 A4 = -1.51124 17th surface	e-05, A6 = 1.	26975e-(07, A8 = -7.2	28488e−10)
						_	k = 0.179 A4 = -2.42938 18th surface	e-05, A6 = -0	6.94876e-	-08, A8 = 3.9	98116e-10)
		Unit mm	l			15	k = 0.132					
	S	urface da	ta			_	A4 = 7.07169e	-06, A6 = 6.3	2887e-07	7, A8 = 9.679	25e-09	
Surface no.	r	d	nd	\mathbf{v} d	θgf		19th surface					
1* 2*	-8.518 -38.017	6.48 0.07	1.53368	55.90	0.563	20	k = -2.890 A4 = 8.40985e 20th surface	-06, A6 = -4.	16581e-0	97, A8 = 2.92	048e-09	
3*	23.626	5.62	1.63490	23.88	0.630							
4* 5*	-13.766 474.790	0.05	1 50264	20.20	0.500		k = -0.632	06.16	1 24005	07.10	44212	NO.
5* 6*	474.790 31.840	0.49 0.05	1.58364	30.30	0.599		A4 = -3.89651 $21th surface$	e-06, A6 = -1	1.34905e-	-0/, A8 = -9	.44213e=(19
7*	9.994	6.43	1.49700	81.61	0.538		z i in suriace					
8*	-22.550	0.06	,			25	k = -1.191					
9	37.796	4.55	1.61800	63.33	0.544		A4 = 5.24213e	-05, A6 = -4.	02486e-0	07, A8 = -1.0)5494e-09)
10	-9.723	0.50	1.72047	34.71	0.583		22th surface					
11	15.791	1.51										
12(Stop) 13	∞ -23.405	0.83	1.72047	34.71	0.583		k = -30.784 A4 = 7.94179e	05 46 4	72042~ (7 49 27	15074~ 00	,
14	18.836	3.04	1.61800	63.33	0.544	30	A4 = 7.941796 A10 = 2.80530		.73842e=()/, A8 = -3.4	150/4e-05	,
15	-24.432	0.05	1101000	00.00		50	23th surface	C-12				
16*	13.826	5.68	1.49700	81.61	0.538		2541 5411400					
17*	-20.280	9.47					k = -0.621					
18*	-10.093	5.91	1.58364	30.30	0.599		A4 = -4.77440		4.56224e-	-08, A8 = -8	.13918e-1	1,
19* 20*	-13.913	3.08	1 50264	20.20	0.500		A10 = -7.8957	2e-12				
21*	-9.681 -7.639	7.68 3.02	1.58364	30.30	0.599	35	24th surface					
22*	-16.165	3.77	1.63490	23.88	0.630		k = -4.243					
23*	-27.283	0.05					A4 = -3.18831	e-04, A6 = 1.	39907e-0	06, A8 = 7.38	3731e-09,	
24*	7.584	5.93	1.53368	55.90	0.563		A10 = -5.0517	6e-11				
25*	3.906	6.00	1.51.640	65.06	0.535		25th surface					
26 27	& &	0.30 5.82	1.51640	65.06	0.535	40	k = -1.870					
Image plane	∞	3.02					A4 = -3.34225	e-04 A6 = 5	68135e=0)6 A8 = -54	12846e-08	:
mage plane						-	A10 = 2.31442		.001556-(70, A0 = -3	120 -100 -00	,
	Aspher	rical surfa	ice data					V	⁄arious da	ta		
1st surface						- ₄₅ -	7k T A				0.00	
k = 0.475							NA Magnifi	ication			0.60 -3.56	
A4 = -8.84441	e-04, $A6 = 6$.	.04064e-(05, A8 = -5.7	6698e-06	5		Focal le				8.92	
2nd surface						_		neight(mm)			7.93	
k = -0.958								(in air) tal length(mm	.) (!= =!=)		12.02	
A4 = -6.68132 3rd surface	e-04, A6 = 5.	.04103e-0	06, A8 = -1.0)3257e-07	7	50 -	Lens to	tai iength(mm	i) (in air)		86.83	
1- 0.470					-			_	-			
k = -0.479 A4 = 2.66301e 4th surface	-05, A6 = 2.4	7046e-07	7, A8 = 1.704	74e-09				Ех	kample	63		
						55						
k = -2.726 A4 = 2.62640e 5th surface	-05, A6 = 1.6	7016e-06	5, A8 = -5.41	971e-09		-			Unit mm			
						_		S	urface da	ta		
k = -2345.875 A4 = -5.83422 6th surface	e-06, A6 =	4.85118e-	-08			60	Surface no.	r	d	nd	νd	θgf
							1*	-7.039	4.91	1.53368	55.90	0.563
k = -0.006							2*	-17.920	0.05			
A4 = 8.68836e	-06, A6 = -4.	.70192e-0)9				3*	15.584	4.58	1.63490	23.88	0.630
7th surface						_	4* 5*	-12.462	0.05	1.40700	01 61	0.520
k = -2.425						65	5* 6*	6.979 -19.498	3.28 0.05	1.49700	81.61	0.538
k = -2.423 A4 = -3.77595	e-05, A6 = -	3.84874e-	-07, $A8 = 5.8$	36446e-09)		7	-19.498 39.995	2.50	1.61800	63.33	0.544
3.11333	- 00,210	ro/ TC	J., 210 - J.C	.5 , 100-05			,	37.773	2.50	1.01000	00.00	J.J . 7

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-continued								-C	ontinue	ed		
		Unit mm				 -			Unit mm			
8 9	-7.177 9.843	0.50 0.80	1.72047	34.71	0.583	5	21th surface					
10(Stop) 11	∞ -13.844	0.58 0.50	1.72047	34.71	0.583							
12	9.243	2.44	1.61800	63.33	0.544		k = -1.845					
13	-20.574	0.05					A4 = -8.86076	6e-04, $A6 = 4$.	64728e-0	5, A8 = -1.4	8831e-06	5,
14*	10.818	3.74	1.49700	81.61	0.538	10	A10 = 2.99535	e-08				
15* 16*	-12.062 -6.434	13.98 6.53	1.58364	30.30	0.599	10						
17*	-5.371	3.16	1.36304	30.30	0.555			V	arious dat	я.		
18*	-11.488	1.97	1.63490	23.88	0.630	_			u110 u5 u4			
19*	-18.115	0.27	1.522.00	55.00	0.563		NA				0.60	
20* 21*	5.193 2.478	3.81 4.35	1.53368	55.90	0.563	15						
22	∞	0.26	1.51640	65.06	0.535	13	Magnif				-3.56	
23	∞	0.91					Focal le				4.98	
Image plane	∞						Image l	neight(mm)			4.75	
	Asnher	ical surfa	ce data			_	fb(mm)	(in air)			5.43	
	Aspliet	var suria	oo uata			- 20	Lens to	tal length(mm) (in air)		59.20	
1st surface												
k = -7.688 $A4 = -5.3082$	8e-03, A6 = 1.0	00779e_0	3. A8 = -3.1	3102e=04	4							
2nd surface				.51026-04		_		Ex	ample (54		
k = 9.824						25						
A4 = -1.9347	6e-03, A6 = 2.	83575e-0	5, A8 = -1.2	27395e-0	5							
3rd surface									T T24			
x = -1.316 A4 = 3.98817e-05, A6 = 1.75107e-07, A8 = 2.54238e-08						-			Unit mm urface dat	a		
4th surface	- 00,110 - 11/1		, 21072			30	Surface no.	r	d	nd	νd	θgf
k = -5.068 A4 = 1.22657	e-04, A6 = 6.73	3445e_06	A8 = -1.01	603e=07		_	1*	-8.599	5.93	1.53368	55.90	0.56
5th surface	v √¬, ∧v = 0./.	J-17JC-00	, 2101.01	.0000-07			2*	-19.840	0.05	1 63 400	22.00	0.63
						- 2-	3* 4*	17.840 -14.375	5.28 0.06	1.63490	23.88	0.63
k = -2.319						35	5*	7.961	3.54	1.49700	81.61	0.53
	9e-05, A6 = -6	5.40124e-	-06, A8 = 1.4	13467e-01	7		6*	-22.188	0.05			
6th surface						_	7	52.926	2.61	1.61800	63.33	0.54
k = 3.388							8 9	-8.538 11.099	0.50 0.96	1.72047	34.71	0.58
	2e-04, $A6 = -1$	1.27410e-	06, A8 = 9.0	01790e-08	3	40	10(Stop)	∞	0.66			
14th surface			,		-	40	11	-15.771	0.50	1.72047	34.71	0.58
						_	12	10.927	2.65	1.61800	63.33	0.54
k = -2.381							13 14*	-21.930 12.592	0.05 4.04	1.49700	Q1 <i>4</i> 1	0.52
	6e-04, $A6 = 1$.	42467e-0	6, A8 = -9.0)1579e-09)		15*	-13.902	15.89	1.49/00	81.61	0.53
15th surface						-	16*	-7.470	7.77	1.58364	30.30	0.59
k = -0.582						45	17*	-6.239	3.85		0.5.5.5	
	6e-05, A6 = -1	l.14010e-	-06, A8 = -9	.41687e-0	09		18* 19*	-13.303 -20.860	2.40	1.63490	23.88	0.63
16th surface						_	19* 20*	-20.860 6.006	0.30 4.42	1.53368	55.90	0.56
						_	21*	2.794	5.00			
k = -0.049	20 04 46 1	27620- 0	5 40 27	15220- 01	7		22	œ	0.30	1.51640	65.06	0.53
A4 = -2.6650. 17th surface	3e-04, $A6 = 1$.	3702Ue=U	3, A8 = -2.7	13338e-01	/	50	23 Image plane	∞ ∞	0.53			
k = -1.101						-		Aspher	rical surfa	ce data		
A4 = 2.022376 18th surface	e-04, $A6 = -2$.	0 8688e- 0	6, A8 = -2.4	18953e-08	8	_	1st surface					
	e-04, A6 = -5.	74254e-0	16, A8 = -5.4	15486e-08	3,	55	k = -6.559 A4 = -3.07798 2nd surface	Se-03, A6 = 7.	19063e-0	14, A8 = -1.4		1
A4 = 2.887236 A10 = -8.2506	070 11					-	k = 8.617 A4 = -1.24859	9e-03, A6 = 1.	39145e-0	15, A8 = -4.3	3338e-07	7
A10 = -8.250 19th surface						60		,		,		
A4 = 2.887236 A10 = -8.2506 19th surface k = -1.062		281746	.∩7 Δ8 = - 1	725320	าร	•	3rd surface					
A4 = 2.887236 A10 = -8.250 19th surface k = -1.062 A4 = -1.8949	7e-04, A6 = -2	2.28174e-	07, A8 = -1	.72532e-0	08,	•						
A4 = 2.887236 A10 = -8.250 19th surface k = -1.062 A4 = -1.8949 A10 = -3.248 20th surface	7e-04, A6 = -2	2.28174e–	-07, A8 = -1	.72532e-(08,	_	k = -1.217 A4 = 2.14714e 4th surface	-05, A6 = 4.9	7776e-07	, A8 = 6.930	13e-09	
A4 = 2.887236 A10 = -8.250 19th surface k = -1.062 A4 = -1.8949 A10 = -3.248 20th surface k = -4.642	7e-04, A6 = -2					- 65	k = -1.217 $A4 = 2.14714e$	-05, A6 = 4.9	7776e-07	, A8 = 6.930	13e-09	

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nuea	-continu

		207							200			
-continued								-(continue	ed		
		Unit mm				_			Unit mm			
5th surface						- <u>-</u>	12(Stop)	œ	0.71			
						- 5	13	-16.523	0.50	1.72047	34.71	0.58
k = -2.297 A4 = -6.0472	1e-05, A6 = -3	3 001532	-06 A8 - 1º	4282	2		14 15	14.445 -18.236	2.57 0.06	1.61800	63.33	0.54
A4 = -6.0472 6th surface	10-00, A0 = -3	,.oz133 e –	00, Ato = 4.8	7202 C -U8	,		15 16*	10.173	4.62	1.49700	81.61	0.53
						_	17*	-14.804	6.97			
k = 3.319	0- 05 46	6 61 224	07 48 22	4630- 00	,	10	18*	-7.554	4.14	1.58364	30.30	0.59
A4 = -8.28348 14th surface	8e-05, A6 = -6).013246-	-0.7, $A8 = 3.2$	4020e-08	,	10	19* 20*	-9.958 -7.176	2.28 4.95	1.61421	25.60	0.62
						_	21*	-5.830	2.02			
k = -2.342							22*	-11.735	2.84	1.63490	23.88	0.63
A4 = -9.16209 15th surface	9e-05, A6 = 8.	36992e-0	7, A8 = -4.4	5060e-09)		23* 24*	-20.945 5.546	0.05 4.33	1.53368	55.90	0.56
13th stillace						15	25*	2.897	4.50	1.55500	33.50	0.50
k = -0.501						- "	26	00	0.30	1.51640	65.06	0.53
A4 = -1.62220 16th surface	0e-05, A6 = -5	,.10344e-	$\cdot 07, A8 = -3.$.96678e=0	19		27 Image plane	& &	3.63			
							mage plane					
	0e-04, A6 = 6.	86575e- 0	16, A8 = -9.7	6272e-08	3	20 -	1 at	Asphe	rical surfa	ice data		
17th surface						_	1st surface					
k = -1.090	e-04, A6 = -1.	07366~ 1	16 AQ = 57	60184 00)		k = 0.659	a_03 A.6 2	35330~ /	04 AQ = 49	21520~ 05	
A4 = 1.454286 $18th surface$	5-04, A0 = -1.	J/3006-0	0, A8 = -3./	09186-05	,		A4 = -2.04816 2nd surface	c-05, A6 = 2.	.JJJ2Ue=()+, A8 = -4.8	51320 e -03	
						- 25						
k = -35.703	e-04, A6 = -2.	80550~ C	16 AV = 10	21002.05		23	k = -1.065 A4 = -1.68684	a_03 A.E. 2	20720~ /	ns A9 = 0.3	05190~ 05	
A4 = 2.125386 A10 = -2.498		0022 96- 0	o, Ao = -1.8	Z100 C -08	,		A4 = -1.08084 3rd surface	c-05, A0 = 2.	27120C-U	JJ, MO = -9.2	:5100 C =0/	
19th surface						_						
k = -1.240							$k = -0.588$ $\Delta 4 = 6.51788e$	_05 A6 = 1 1	31630 04	5 AR = 1 057	724e_09	
	4e-04, A6 = -2	2.05558e-	-07, A8 = -4	.46527e=0	9,	30	A4 = 6.51788e 4th surface	-∪ɔ, Ato = 1.1	21036-00), Ao = 1.93/	∠ 4 €−08	
A10 = -7.3014			.,		,							
20th surface						_	k = -2.720	05 46 77	6272 . 01	C A D D D D	(030° 06	
k = -4.876							A4 = 6.41977e 5th surface	-05, A0 = 7.0	03/36-00	J, Alo = −3.80	00200-08	
A4 = -8.70533	3e-04, $A6 = 5$.	71807e-0	6, A8 = 5.33	843e-08,								
A10 = -2.8780 21th surface	01e-10					35	k = -1871.246 A4 = -1.46877	e=05 A6 =	7 704885	-07		
21010011400						_	A4 = -1.46877 6th surface	- 05, A0 = -	L., / TOOC	3,		
k = -1.928	1- 04 46 1	04471 1) E AO 0 0	0007- 07	,		1. 0.004					
A4 = -3.5643 A10 = 3.8980	1e-04, A6 = 1. 3e-09	J44/1e-0	5, A8 = -2.6	บชช:/e=07	,		k = -0.064 A4 = 2.14004e	-05. A6 = 4 3	9293e=08	3		
						- 40	7th surface		. 2, 50-00			
	V	arious dat	ta			_	lr _ 2 422					
NA				0.60		-	k = -2.423		1.73930e-	-06. A8 = 5.1	2031e=08	
Magni	fication			-3.56			A4 = -9.35989	e - 05. $A6 = -$				
Focal 1	ength						A4 = -9.359898th surface	e-05, A6 = -		,		
	haiabt()			5.34			8th surface	e-05, A6 = -				
Image	height(mm)) (in air)			5.50		45	8th surface k = 1.436					
Image fb(mm	height(mm)) (in air) otal length(mm) (in air)				45	8th surface k = 1.436 A4 = -7.63094					
Image fb(mm) (in air)) (in air)		5.50 5.73		45 -	8th surface k = 1.436 A4 = -7.63094 16th surface					
Image fb(mm) (in air) otal length(mm	<u> </u>		5.50 5.73		45	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670	e-05, A6 = 4.	05361e-(07, A 8 = 1.19	9948e-08	
Image fb(mm) (in air) otal length(mm	(in air)		5.50 5.73		-	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307	e-05, A6 = 4.	05361e-(07, A 8 = 1.19	9948e-08	
Image fb(mm) (in air) otal length(mm	<u> </u>	65	5.50 5.73		45 - 50	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670	e-05, A6 = 4.	05361e-(07, A 8 = 1.19	9948e-08	
Image fb(mm) (in air) otal length(mm	<u> </u>	65	5.50 5.73		-	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072	e-05, A6 = 4. e-05, A6 = 5.	05361e-(41575e-(07, A8 = 1.19 $07, A8 = -3.8$	9948e-08 39066e-09	
Image fb(mm) (in air) otal length(mm	kample (5.50 5.73		-	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183	e-05, A6 = 4. e-05, A6 = 5.	05361e-(41575e-(07, A8 = 1.19 $07, A8 = -3.8$	9948e-08 39066e-09	
Image fb(mm) (in air) otal length(mm	cample (5.50 5.73		-	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface	e-05, A6 = 4. e-05, A6 = 5.	05361e-(41575e-(07, A8 = 1.19 $07, A8 = -3.8$	9948e-08 39066e-09	
Image fb(mm Lens to) (in air) ttal length(mm Ex	cample (Unit mm	ia	5.50 5.73 67.24		-	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 =	05361e-(41575e-(2.19847e-	07, A8 = 1.19 07, A8 = -3.8 -07, A8 = 6.0	9948e-08 39066e-09 97739e-09	
Image fb(mm) (in air) otal length(mm	cample (5.50 5.73	θgf	5 0	k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 =	05361e-(41575e-(2.19847e-	07, A8 = 1.19 07, A8 = -3.8 -07, A8 = 6.0	9948e-08 39066e-09 97739e-09	
Image fb(mm Lens to) (in air) tal length(mm Ex	Unit mm urface dat d 4.80	ia	5.50 5.73 67.24	θgf 0.563	5 0	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 =	05361e-(41575e-(2.19847e-	07, A8 = 1.19 07, A8 = -3.8 -07, A8 = 6.0	9948e-08 39066e-09 97739e-09	
Image fb(mm Lens to) (in air) tal length(mm Ex	Unit mm urface dat d 4.80 0.05	nd 1.53368	5.50 5.73 67.24 vd 55.90	0.563	5 0	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e 19th surface	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 = -06, A6 = 2.2	05361e-(41575e-(2.19847e- 5429e-06	0.07, A.8 = 1.19 $0.07, A.8 = -3.8$ $0.07, A.8 = -3.8$ $0.07, A.8 = 6.0$ $0.07, A.8 = 6.0$ $0.07, A.8 = 6.0$	0948e-08 89066e-05 07739e-05	
Image fb(mm Lens to) (in air) tal length(mm Ex	Unit mm urface dat d 4.80	ia nd	5.50 5.73 67.24		5 0	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e 19th surface k = -2.920	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 = -06, A6 = 2.2	05361e-(41575e-(2.19847e- 5429e-06	0.07, A.8 = 1.19 $0.07, A.8 = -3.8$ $0.07, A.8 = -3.8$ $0.07, A.8 = 6.0$ $0.07, A.8 = 6.0$ $0.07, A.8 = 6.0$	0948e-08 89066e-05 07739e-05	
Surface no. 1* 2* 3* 4* 5*	Si r -6.269 -27.398 17.424 -10.162 329.227	Unit mm urface dat d 4.80 0.05 4.12 0.05 0.61	nd 1.53368	5.50 5.73 67.24 vd 55.90	0.563	50	k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e 19th surface k = -2.920 A4 = 2.34541e 20th surface	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 = -06, A6 = 2.2	05361e-(41575e-(2.19847e- 5429e-06	0.07, A.8 = 1.19 $0.07, A.8 = -3.8$ $0.07, A.8 = -3.8$ $0.07, A.8 = 6.0$ $0.07, A.8 = 6.0$ $0.07, A.8 = 6.0$	0948e-08 89066e-05 07739e-05	
Image fb(mm Lens to Le	Si r -6.269 -27.398 17.424 -10.162 329.227 23.639	Unit mm urface dat d 4.80 0.05 4.12 0.05 0.61 0.05	nd 1.53368 1.63490 1.58364	vd 55.90 23.88 30.30	0.563 0.630 0.599	50	k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e 19th surface k = -2.920 A4 = 2.34541e 20th surface k = -0.618	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 = -1.	05361e-(41575e-(2.19847e- 5429e-0(70730e-(07, A8 = 1.19 07, A8 = -3.8 -07, A8 = 6.0 5, A8 = 5.404	9948e-08 89066e-09 97739e-09 813e-08	
Surface no. 1* 2* 3* 4* 5*	Ex Si r -6.269 -27.398 17.424 -10.162 329.227 23.639 7.301	Unit mm urface dat d 4.80 0.05 4.12 0.05 0.61 0.05 4.38	nd 1.53368 1.63490	vd 55.90 23.88	0.563 0.630	50	k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e 19th surface k = -2.920 A4 = 2.34541e 20th surface	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 = -1.	05361e-(41575e-(2.19847e- 5429e-0(70730e-(07, A8 = 1.19 07, A8 = -3.8 -07, A8 = 6.0 5, A8 = 5.404	9948e-08 89066e-09 97739e-09 813e-08	
Image fb(mm Lens to Le	State -6.269 -27.398 17.424 -10.162 329.227 23.639 7.301 -16.656 26.802	Unit mm urface dat d 4.80 0.05 4.12 0.05 0.61 0.05 4.38 0.05 3.49	nd 1.53368 1.63490 1.58364 1.49700 1.61800	vd 55.90 23.88 30.30 81.61 63.33	0.563 0.630 0.599 0.538 0.544	50 - - - 55 -	8th surface k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e 19th surface k = -2.920 A4 = 2.34541e 20th surface k = -0.618 A4 = -1.37263 21th surface	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 = -1.	05361e-(41575e-(2.19847e- 5429e-0(70730e-(07, A8 = 1.19 07, A8 = -3.8 -07, A8 = 6.0 5, A8 = 5.404	9948e-08 89066e-09 97739e-09 813e-08	
Image fb(mm Lens to Le	Ex Si r -6.269 -27.398 17.424 -10.162 329.227 23.639 7.301 -16.656	Unit mm urface dat d 4.80 0.05 4.12 0.05 0.61 0.05 4.38 0.05	nd 1.53368 1.63490 1.58364 1.49700	vd 55.90 23.88 30.30 81.61	0.563 0.630 0.599 0.538	50	k = 1.436 A4 = -7.63094 16th surface k = -1.670 A4 = -3.89307 17th surface k = 0.072 A4 = -6.09183 18th surface k = 0.089 A4 = 9.88125e 19th surface k = -2.920 A4 = 2.34541e 20th surface k = -0.618 A4 = -1.37263	e-05, A6 = 4. e-05, A6 = 5. e-05, A6 = -2. -06, A6 = 2.2 -05, A6 = -1.	05361e-(41575e-(2.19847e- 5429e-0(70730e-(1.25116e-	07, A8 = 1.19 07, A8 = -3.8 -07, A8 = -6.0 5, A8 = 5.404 06, A8 = 1.38 -06, A8 = -8	9948e-08 89066e-09 97739e-09 413e-08 8533e-08	18

-0>			
-continued			

		Unit mm					Unit mm
22th surface						- 5	2nd surface
k = -30.535 A4 = 2.125966 A10 = 2.49260 23th surface	e-04, A6 = -2 0e-11	32471e-0	16, A8 = -3.1	8933e-08	3,	_	k = -4.154 A4 = -1.67302e-03, A6 = 2.41417e-05, A8 = -9.14504e-07 3rd surface
A10 = -1.3109	0e-04, A6 = -1 91e-10	l.76460e-	·07, A8 = 8.5	1270e-10),	10	k = -0.713 A4 = 6.22862e-05, A6 = 1.21873e-06, A8 = 2.05895e-08 4th surface
24th surface k = -4.296 A4 = -8.13846 A10 = -7.0135	6e-04, A6 = 6.	17276e-0	96, A8 = 7.50	056e-08,		15	k = -2.747 A4 = 6.54960e-05, A6 = 7.63953e-06, A8 = -3.72649e-08 5th surface k = -2888.742
25th surface						_	A4 = -1.51322e-05, A6 = -1.13362e-07 6th surface
k = -1.860 $A4 = -8.20694$ $A10 = 5.58526$	4e-04, A6 = 2.7 6e-09	7771 8e –0	15, A8 = -5.2	4812e-07	7,	20	k = -0.115 A4 = 2.12292e-05, A6 = -4.40257e-08 7th surface
	V	arious dat	ta				
Focal l				0.60 -3.56 6.16		25	k = -2.422 A4 = -9.18841e-05, A6 = -1.69650e-06, A8 = 4.50496e-08 8th surface
fb(mm	height(mm)) (in air) otal length(mm	.) (in air)		5.50 8.33 63.71		25	k = 1.359 A4 = -7.73141e-05, A6 = 3.20836e-07, A8 = 1.45375e-08 16th surface
	Ex	cample (66			30	k = -1.661 A4 = -3.80858e-05, A6 = 6.00548e-07, A8 = -3.31015e-09 17th surface
						_	k = 0.087 A4 = -6.24513e-05, A6 = -2.33471e-07, A8 = 7.81939e-09 18th surface
		Unit mm				- 35	k = 0.116
~ ^		urface dat				-	A4 = 6.47632e-06, A6 = 1.93794e-06, A8 = 8.75430e-08 19th surface
Surface no. 1*	-6.744	d 4.55	nd 1.53368	vd 55.90	θgf 0.563	-	k = -2.967
2*	-28.324	0.05				40	A4 = 3.57609e-05, A6 = -1.49735e-06, A8 = 2.83588e-08 20th surface
3* 4*	17.647 -10.252	4.11 0.05	1.63490	23.88	0.630	-10	1 0.611
4.	368.125	0.03	1.58364	30.30			k = -0.611
5*					0.599		$\Delta A = -1.58294e - 05$ $\Delta A = -1.07032e - 06$ $\Delta R = -9.97644e - 08$
5* 6*	23.485	0.05			0.599		A4 = -1.58294e - 05, $A6 = -1.07032e - 06$, $A8 = -9.97644e - 0821th surface$
6 * 7 *	23.485 7.303	3.75	1.49700	81.61	0.599		A4 = -1.58294e-05, A6 = -1.07032e-06, A8 = -9.97644e-08 21th surface
6* 7* 8*	23.485 7.303 -16.608	3.75 0.05	1.49700		0.538	45	21th surface k = -1.189
6* 7* 8* 9	23.485 7.303 -16.608 27.992	3.75 0.05 3.48	1.49700 1.61800	63.33	0.538 0.544	45	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08
6* 7* 8* 9	23.485 7.303 -16.608 27.992 -7.240	3.75 0.05 3.48 0.50	1.49700		0.538	45	21th surface k = -1.189
6* 7* 8* 9 10	23.485 7.303 -16.608 27.992	3.75 0.05 3.48	1.49700 1.61800	63.33	0.538 0.544	45	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface
6* 7* 8* 9 10 11 12(Stop)	23.485 7.303 -16.608 27.992 -7.240 11.712 \$\infty\$	3.75 0.05 3.48 0.50 0.93 0.68 0.50	1.49700 1.61800 1.72047	63.33 34.71	0.538 0.544 0.583	45	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08
6* 7* 8* 9 10 11 12(Stop) 13	23.485 7.303 -16.608 27.992 -7.240 11.712 60 -16.247 14.941	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48	1.49700 1.61800 1.72047	63.33 34.71	0.538 0.544 0.583		21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11
6* 7* 8* 9 10 11 12(Stop) 13 14	23.485 7.303 -16.608 27.992 -7.240 11.712 6 -16.247 14.941 -17.172	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05	1.49700 1.61800 1.72047 1.72047 1.61800	63.33 34.71 34.71 63.33	0.538 0.544 0.583 0.583 0.544	45 50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08,
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16*	23.485 7.303 -16.608 27.992 -7.240 11.712 	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04	1.49700 1.61800 1.72047	63.33 34.71	0.538 0.544 0.583		21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17*	23,485 7,303 -16,608 27,992 -7,240 11,712 -16,247 14,941 -17,172 10,250 -14,686	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700	63.33 34.71 34.71 63.33 81.61	0.538 0.544 0.583 0.583 0.544 0.538		21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16*	23.485 7.303 -16.608 27.992 -7.240 11.712 	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04	1.49700 1.61800 1.72047 1.72047 1.61800	63.33 34.71 34.71 63.33	0.538 0.544 0.583 0.583 0.544		21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09,
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18*	23,485 7,303 -16,608 27,992 -7,240 11,712 60 -16,247 14,941 -17,172 10,250 -14,686 -7,433 -10,047 -6,674	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700	63.33 34.71 34.71 63.33 81.61	0.538 0.544 0.583 0.583 0.544 0.538		21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21*	23,485 7,303 -16,608 27,992 -7,240 11,712 60 -16,247 14,941 -17,172 10,250 -14,686 -7,433 -10,047 -6,674 -5,707	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 5.39 2.10	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421	63.33 34.71 34.71 63.33 81.61 30.30 25.60	0.538 0.544 0.583 0.583 0.544 0.538 0.599		21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22*	23,485 7,303 -16,608 27,992 -7,240 11,712 -16,247 14,941 -17,172 10,250 -14,686 -7,433 -10,047 -6,674 -5,707 -11,710	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 5.39 2.10 2.68	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364	63.33 34.71 34.71 63.33 81.61 30.30	0.538 0.544 0.583 0.583 0.544 0.538 0.599	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22* 23*	23.485 7.303 -16.608 27.992 -7.240 11.71216.247 14.941 -17.172 10.250 -14.686 -7.433 -10.047 -6.674 -5.707 -11.710 -20.113	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 5.39 2.10 2.68 0.08	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421 1.63490	63.33 34.71 34.71 63.33 81.61 30.30 25.60 23.88	0.538 0.544 0.583 0.583 0.544 0.538 0.599 0.621	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08,
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22* 23* 24*	23,485 7,303 -16,608 27,992 -7,240 11,712 6 -16,247 14,941 -17,172 10,250 -14,686 -7,433 -10,047 -6,674 -5,707 -11,710 -20,113 5,560	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 5.39 2.10 2.68 0.08	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421	63.33 34.71 34.71 63.33 81.61 30.30 25.60	0.538 0.544 0.583 0.583 0.544 0.538 0.599	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08, A10 = -5.38583e-10
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22* 23*	23.485 7.303 -16.608 27.992 -7.240 11.71216.247 14.941 -17.172 10.250 -14.686 -7.433 -10.047 -6.674 -5.707 -11.710 -20.113	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 5.39 2.10 2.68 0.08	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421 1.63490	63.33 34.71 34.71 63.33 81.61 30.30 25.60 23.88	0.538 0.544 0.583 0.583 0.544 0.538 0.599 0.621	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08,
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22* 23* 24* 25* 26 27	23,485 7,303 -16,608 27,992 -7,240 11,712 6 -16,247 14,941 -17,172 10,250 -14,686 -7,433 -10,047 -6,674 -5,707 -11,710 -20,113 5,560 2,881 6 6	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 5.39 2.10 2.68 0.08	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421 1.63490 1.53368	63.33 34.71 34.71 63.33 81.61 30.30 25.60 23.88 55.90	0.538 0.544 0.583 0.583 0.544 0.538 0.599 0.621 0.630 0.563	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08, A10 = -5.38583e-10 25th surface
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22* 23* 24* 25* 26	23.485 7.303 -16.608 27.992 -7.240 11.712 6 -16.247 14.941 -17.172 10.250 -14.686 -7.433 -10.047 -6.674 -5.707 -11.710 -20.113 5.560 2.881 6 6	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 2.10 2.68 0.08 4.27 4.50 0.30 2.87	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421 1.63490 1.53368 1.51640	63.33 34.71 34.71 63.33 81.61 30.30 25.60 23.88 55.90	0.538 0.544 0.583 0.583 0.544 0.538 0.599 0.621 0.630 0.563	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08, A10 = -5.38583e-10 25th surface k = -1.870 A4 = -7.81641e-04, A6 = 2.80809e-05, A8 = -5.72873e-07,
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 22* 23* 24* 25* 26 27 Image plane	23.485 7.303 -16.608 27.992 -7.240 11.712 6 -16.247 14.941 -17.172 10.250 -14.686 -7.433 -10.047 -6.674 -5.707 -11.710 -20.113 5.560 2.881 6 6	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 5.39 2.10 2.68 0.08 4.27 4.50 0.30	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421 1.63490 1.53368 1.51640	63.33 34.71 34.71 63.33 81.61 30.30 25.60 23.88 55.90	0.538 0.544 0.583 0.583 0.544 0.538 0.599 0.621 0.630 0.563	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08, A10 = -5.38583e-10 25th surface k = -1.870 A4 = -7.81641e-04, A6 = 2.80809e-05, A8 = -5.72873e-07, A10 = 6.43070e-09
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21* 22* 23* 24* 25* 26 27	23.485 7.303 -16.608 27.992 -7.240 11.712 6 -16.247 14.941 -17.172 10.250 -14.686 -7.433 -10.047 -6.674 -5.707 -11.710 -20.113 5.560 2.881 6 6	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 2.10 2.68 0.08 4.27 4.50 0.30 2.87	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421 1.63490 1.53368 1.51640	63.33 34.71 34.71 63.33 81.61 30.30 25.60 23.88 55.90	0.538 0.544 0.583 0.583 0.544 0.538 0.599 0.621 0.630 0.563	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08, A10 = -5.38583e-10 25th surface k = -1.870 A4 = -7.81641e-04, A6 = 2.80809e-05, A8 = -5.72873e-07,
6* 7* 8* 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 221* 22* 23* 24* 25* 26 27 Image plane	23.485 7.303 -16.608 27.992 -7.240 11.712 6 -16.247 14.941 -17.172 10.250 -14.686 -7.433 -10.047 -6.674 -5.707 -11.710 -20.113 5.560 2.881 6 6	3.75 0.05 3.48 0.50 0.93 0.68 0.50 2.48 0.05 5.04 7.09 3.40 2.59 2.10 2.68 0.08 4.27 4.50 0.30 2.87	1.49700 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.61421 1.63490 1.53368 1.51640	63.33 34.71 34.71 63.33 81.61 30.30 25.60 23.88 55.90	0.538 0.544 0.583 0.583 0.544 0.538 0.599 0.621 0.630 0.563	50	21th surface k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08 22th surface k = -30.969 A4 = 2.14284e-04, A6 = -2.50014e-06, A8 = -3.94482e-08, A10 = 1.75181e-11 23th surface k = 0.274 A4 = -1.40593e-04, A6 = -2.34596e-07, A8 = -2.72736e-09, A10 = -1.34264e-10 24th surface k = -4.460 A4 = -8.31533e-04, A6 = 6.06058e-06, A8 = 7.30319e-08, A10 = -5.38583e-10 25th surface k = -1.870 A4 = -7.81641e-04, A6 = 2.80809e-05, A8 = -5.72873e-07, A10 = 6.43070e-09

	-(211 continue	ed					-	212 continue	ed		
		Unit mm				-			Unit mm			
Focal le	ngth			5.82		-	8th surface					
fb(mm)	eight(mm) (in air) al length(mm	ı) (in air)		5.23 7.57 62.10		5	k = 1.432 A4 = -1.17 16th surface	703e-05, A6 = 2	10026e-0	98, A8 = 1.62	2417e-10	
	Ez	kample (67			10	k = -1.632 A4 = -6.09 17th surface	995e-06, A6 = 2	72227e-0	98, A8 = -7.6	50562e-11	
						•	k = 0.162 A4 = -9.42 18th surface	741e-06, A6 = -	·1.49326e-	-08, A8 = 6.0	00257e-11	
		Unit mm				15	k = 0.151	·				
	s	urface dat	a			_		21e-06, A6 = 1.0	05693e-07	, A8 = 8.446	21e-10	
Surface no.	r	d	nd	vd	θgf		19th surface	•				
1*	-11.654	8.90	1.53368	55.90	0.563	20	k = -2.829 A4 = 3.815	19e-06, A6 = -6	5.91852e=0	08, A8 = 2.58	3538e-10	
2* 3*	-53.270 32.497	0.09 7.73	1.63490	23.88	0.630	20	20th surface	•				
4*	-18.865	0.05					k = -0.623					
5* 6*	609.908	0.55	1.58364	30.30	0.599			444e-06, A6 = -	·3.72162e-	-08, A8 = -1	.04792e=0)9
6* 7*	43.689 13.655	0.05 8.70	1.49700	81.61	0.538		21th surface)				
8*	-30.942	0.05				25	k = -1.166					
9	54.201	6.26	1.61800	63.33	0.544			28e-05, A6 = -9	0.68055e=0	98, A8 = -1.1	1067e-10)
10 11	-13.279 21.817	0.50 2.42	1.72047	34.71	0.583		22th surface					
12(Stop)	∞	1.14					k = -30.999)				
13	-31.961	0.52	1.72047	34.71	0.583		A4 = 2.8868	86e-05, A6 = -9	.73152e-0	08, A8 = -4.0	6882e-10),
14	25.513	4.08	1.61800	63.33	0.544	30	A10 = 1.903					
15 16*	-33.246 18.998	0.15 8.40	1.49700	81.61	0.538		23th surface					
17*	-27.856	12.95	1.12700	01.01	0.550		k = -1.442					
18*	-14.193	8.09	1.58364	30.30	0.599		A4 = -1.86	8386-05, A6 = -	-1.599486-	-08, A8 = -2	2.14349e-	11,
19* 20*	-19.094 -13.249	4.04 10.54	1.58364	30.30	0.599		A10 = -4.11					
21*	-13.249 -10.558	4.39	1.20304	50.50	<i>∪.</i>	35	24th surface					
22*	-22.376	5.26	1.63490	23.88	0.630		k = -4.203					
23* 24*	-37.463 10.448	0.05 8.01	1.53368	55.90	0.563			702e-04, $A6 = 3$.03286e-0	97, A8 = 8.98	8650e-10,	
25*	5.391	8.22	1.55500	33.30	0.303		A10 = -3.2 25th surface					
26	∞	0.30	1.51640	65.06	0.535	40						
27 Image plane	∞ ∞	8.21				-10	k = -1.867	264- 04 46 1	20962- 6	A A D	24620 - 00	,
Image plane						-	A4 = -1.38 A10 = 1.39	264e-04, A6 = 1 250e-11	.20863e-(70, A8 = -5.8	54039e-09	΄,
	Asphe	rical surfa	ce data			-		,	Various da	ta		
1st surface						- 45	NA				0.60	
k = 1.075					_		Magni	fication			-3.55	
A4 = -3.077426 2nd surface	e-04, A6 = 9	.467/48e=0	6, A8 = -3.9	25246e-07	′		Focal I				12.29	
znu suriace						-		height(mm)) (in air)			10.82 16.62	
k = 0.243 A4 = -2.624866 3rd surface	e-04, A6 = 1	.05472e-0	6, A8 = -1.1	.2886e-08	3	50		otal length(mm)	(in air)		119.56	
k = -0.422						_		T.	vomale	68		
A4 = 1.05645e- 4th surface	-05, A6 = 4.9	9657e-08	, A8 = 2.125	51e-10				Е	xample	00		
k = -2.716 A4 = 1.02640e-	-05, A6 = 3.3	6920e-07	, A8 = -5.29	009e-10		55			Unit mm			
5th surface						_			Sumface 4 :	-0		
k = -1981.989 A4 = -2.50643	e-06, A6 = -	1.03156e-	-08				Surface no.	r	Surface dat d	nd	νd	θε
6th surface	,					60 -	1*					
k = 0.024							2*	-63.538 32.204	10.02 0.05	1.85135	40.10	0.5
A4 = 3.45165e	-06, A6 = -4	.51348e-1	1				3*	32.533	7.00	1.53368	55.90	0.5
7th surface						_	4* 5*	-106.297	0.26	1.40700	Q1 £1	0.5
								54.300	10.00	1.49700	81.61	0.5
k = -2.412						65	6*	-23.738	0.98			

A4 = 1.24700e - 05, A6 = 2.89708e - 10, A8 = 3.47525e - 11

A4 = 3.37433e-06, A6 = 3.63821e-09, A8 = 5.61429e-11

11th surface

k = 1.839

214

tinued	-continued

-continued -unit mm							-continued		
							Unit mm		
k	-97.520	0.06					12th surface		
	105.081	8.88	1.63490	23.88	0.630	5			
	-33.023	0.42	4.500.64				k = -10.495	0 000007 44	
	-38.264	2.80 0.07	1.58364	30.30	0.599		A4 = -1.54011e-05, $A6 = -1.49070e-09$, A 17th surface	18 = 3.2309/e - 11	
	53.734 62.691	11.68	1.49700	81.61	0.538		17th surface		
	-22.596	5.75	1.72047	34.71	0.583		k = 0.528		
	-112.813	3.53	1.72017	5 1.71	0.505	10	A4 = -5.62809e-07, A6 = -5.77511e-09, A	8 = -1.61623e-11	
Stop)	∞	-1.56					18th surface		
• /	70.148	2.54	1.53368	55.90	0.563				
	-183.515	0.24					k = -142.321		
	-284.510	8.92	1.49700	81.61	0.538		A4 = 4.44624e - 06, $A6 = 9.06780e - 09$, $A8 = 4.44624e - 06$	= -3.00760e - 11	
	-28.520	8.41	1.72047	34.71	0.583		23th surface		
	198.897	17.49	1.49700	81.61	0.538	15			
	-40.316	16.34	1 04666	22.70	0.620		k = -1.909	0 4 40640 - 10	
	93.660 212.953	5.46 16.44	1.84666	23.78	0.620		A4 = -9.55582e - 07, $A6 = -2.84663e - 09$, $A6 = -2.84669$, $A6 = -2.8466$	18 = 4.48049e-12	
	25.378	9.46	1.53368	55.90	0.563		24th stirrace		
	-119.565	0.48	1.55500	33.70	0.505		k = -158.290		
	52.177	9.92	1.53368	55.90	0.563	20	A4 = -2.56151e - 06, $A6 = -1.96788e - 09$, $A6 = -1.96788e - 09$	8 = 4.34014e - 12	
	10.383	12.85				20	25th surface		
	-44.349	7.33	1.53368	55.90	0.563				
	-53.218	2.07					k = -1.408		
	-20.191	10.09	1.53368	55.90	0.563		A4 = -7.29707e - 06, $A6 = -3.93011e - 09$, $A6 = -3.93011e - 09$	8 = -1.35076e - 11	
	50.820	2.00					26th surface		
	∞	0.30	1.51640	65.06	0.535	25			
	∞	1.80				23	k = -36.249	0.04770 40	
ge plane	∞					_	A4 = 6.21711e-07, $A6 = -2.35958e-09$, $A827th surface$	s = -9.91 / /Ue-12	
	Asph	erical surfa	ce data						
1						_	k = -11.909 A4 = -5.75821e-06, A6 = 3.19672e-08, A8	/ 3128/a_11	
1st surface						— 30	28th surface	4.512640-11	
k = 4.443 A4 = -1.05776e-04, A6 = -3.64425e-07, A8 = 1.98904e-09 2nd surface							k = -1.033 A4 = -2.20475e-05, A6 = 7.79789e-08, A8 = 9.56535e-11		
						_	29th surface		
k = -19.238 A4 = -3.91023e-05, A6 = -3.11804e-08, A8 = -5.67242e-11 3rd surface						35	k = 5.439 A4 = -2.60359e-05, A6 = 9.13286e-08, A8 = 2.72747e-12 30th surface		
k = -20.954 A4 = 2.62599e-06, A6 = 1.82851e-08, A8 = 4.54659e-11							k = 2.910 A4 = -1.84445e-06, A6 = 5.39362e-08, A8 = -9.42280e-11		
4th surface						_ 40	21th gurfage		
k = 9.940							k = -0.869		
	1900e-05, A6 = 9	9.03155e-0	9, A8 = 1.79	9996e-10			A4 = 3.33460e-05, A6 = -1.85661e-08, A8 = 8.80359e-11		
5th surface	e					_	32th surface		
k = 1.123							k = -24.510		
	856e-07, A6 = -3	3 15865e-0	18 A8 - 3 4C	9785e_11		45	A4 = -1.19291e - 05, $A6 = -5.06023e - 10$, $A8 = -1.47595e - 11$		
6th surface		J.1J00J0-0	.0, 210 - 3.43	.,050-11		-			
l- 2.027	7						Various data		
k = -2.027		047475 09	18 - 6022	007a 11			NA	0.60	
	357e-06, $A6 = 2$.	.u4/4/e-U8	, Ao = 0.932	.y/C-11			Magnification	-3.51	
7th surface						_ 50	Focal length	7.51	
k = 2.496							Image height(mm)	20.78	
A4 = -4.68859e - 06, $A6 = -7.75345e - 09$, $A8 = 6.02390e - 11$					1		fb(mm) (in air) Lens total length(mm) (in air)	4.00 196.17	
8th surface	,	,55450-				_	Lens total length(lilin) (in an)	150.17	
k = 3.339						- 55			
						55	Evample 60		
A4 = 3.50988e-07, A6 = 2.15482e-08, A8 = -2.56013e-11 9th surface							Example 69		
						_			
k = 3.604 A4 = 1.203	384e-07, A6 = 1.	78755e-08	4, A8 = -3.15	5317e-13		-	** **		
10th surface						_ 60 _	Unit mm		
							C C 1.4.		

60	Unit mm												
	Surface data												
	Surface no.	r	d	nd	νd	θgf							
65	1* 2*	-29.955 21.219	5.67 0.05	1.85135	40.10	0.569							
	3*	26.565	3.07	1.53368	55.90	0.563							

A4 = 1.03539e-04, A6 = -6.33943e-08, A8 = 4.04592e-09

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213	210
ontinued	-continued

	-	continue	ed				-continued	
		Unit mm					Unit mm	
4*	-29.352	0.05				 5	11th surface	
5* 6*	27.194 -12.447	4.58 0.05	1.49700	81.61	0.538	3		
7*	41.662	1.69	1.49700	81.61	0.538		k = 1.941	7.669272 00
8*	-59.590	0.05					A4 = 2.37787e-05, A6 = 1.62382e-07, A8 = 12th surface	= 7.00827e=09
9*	44.366	3.67	1.63490	23.88	0.630		12th striace	
0* 1*	-17.202	0.50	1.58364	30.30	0.599	10	k = -10.761	
2*	-19.670 30.021	1.21 0.20	1.36304	30.30	0.399	10	A4 = -1.30990e - 04, $A6 = -1.71078e - 07$, A	8 = 5.02262e - 09
.3	23.366	5.25	1.49700	81.61	0.538		17th surface	
4	-12.616	0.50	1.72047	34.71	0.583		1 0.007	
5	68.194	2.31					k = -0.267 A4 = -1.00551e-05, $A6 = -2.52136e-07$, A	9 - 4 24466a 10
6(Stop) 7*	∞ 21.245	-1.10 1.85	1.53368	55.90	0.563	1.5	A4 = -1.00331e - 03, $A0 = -2.32130e - 07$, A 18th surface	8 = 4.24400e-10
8*	-93.246	0.09	1.55500	33.30	0.505	15	10th Stifface	
9	-148.608	2.90	1.49700	81.61	0.538		k = -207.405	
0	-12.601	1.24	1.72047	34.71	0.583		A4 = 2.84376e-05, A6 = 3.79772e-07, A8 =	-4.21658e-09
1	37.919	4.85	1.49700	81.61	0.538		23th surface	
!2 !3*	-24.743 34.680	6.71	1.84666	23.78	0.620			
.3* !4*	92.807	2.10 9.47	1.04000	23.76	0.020	20	k = -1.706	
.5*	12.166	7.28	1.53368	55.90	0.563		A4 = -7.10617e - 06, $A6 = -8.60971e - 08$, A	8 = 7.01716e-10
£6 *	-40.917	0.63		-			24th surface	
.7*	40.697	4.65	1.53368	55.90	0.563		k = -186.451	
8*	5.464	4.96					A4 = -2.28317e - 05, $A6 = -6.42653e - 08$, A	8 = 6.74174e-10
9* 60*	69.863 -23.297	4.34	1.53368	55.90	0.563	25	25th surface	01/11/10 10
1*	-23.297 -8.406	2.44 3.04	1.53368	55.90	0.563			
2*	13.145	2.00	1.55500	55.50	0.505		k = -1.569	
3	00	0.30	1.51640	65.06	0.535		A4 = -6.55071e - 05, $A6 = -2.05782e - 07$, A	8 = -4.37955e - 09,
4	∞	0.95					A10 = -2.52773e - 14	
mage plane	∞					30	26th surface	
1st surface	Aspho	erical surfa	ce data			- -	k = -3.839 A4 = -8.01566e-06, A6 = -2.54791e-07, A A10 = -2.54003e-14 27th surface	8 = -1.15935e-09,
	k = -2.844 A4 = -5.95233e-04, A6 = -2.01185e-05, A8 = -4.04057e-08 2nd surface				35	k = -34.425 A4 = -4.77157e-05, A6 = 1.08255e-06, A8 28th surface	= -4.06557e-09	
k = -26.594 $A4 = -2.913$ 3rd surface	563e-04, A6 = 3	3.38545e-0	8, A8 = -4.4	8601e-09)	_ 40	k = -1.002 A4 = -1.54742e-04, A6 = 2.47821e-06, A8 29th surface	= -3.91574e-09
k = -38.988 A4 = 1.3103 4th surface	3 76e-05, A6 = 1.3	39853e-07	, A8 = 7.030	94e-09		_	k = -50.008 A4 = -5.21414e-05, A6 = 4.83615e-07, A8 A10 = 1.50137e-12	= -8.84765e-09,
k = 7.191 A4 = -8.198 5th surface	846e-05, A6 = -	-3.06820e–	07, A8 = 2.4	7340e-08	3	45	30th surface k = -29.019	
k = 1.384 A4 = 5.0853 6th surface	76e-06, A6 = -7	7.77373e-0	7, A8 = 6.23	909e-09			A4 = 1.22863e-04, A6 = 8.90770e-07, A8 = A10 = 5.46743e-13 31th surface	= -5.28257e-09,
k = -1.761	54e-05, A6 = 4.	86920e-07	, A8 = 6.060	03e-09		_ ⁵⁰ _	k = -0.773 A4 = 3.16385e-04, A6 = 9.74440e-08, A8 = A10 = -5.53413e-14 32th surface	= 1.40543e-08,
k = -14.126 $A4 = -5.353$ 8th surface	357e-05, A6 = -	-2.25010e-	07, A8 = 6.8	8366e-09)	55	k = -16.868 A4 = -1.76589e-04, A6 = 8.02882e-07, A8 A10 = -1.70931e-12	= -7.40507e-09,
k = -2.133 A4 = 1.0586 9th surface	64e-05, A6 = 6.9	95122e-07	, A8 = -3.15	146e-09		60	Various data	
k = 3.451	95e-06, A6 = 4.	87778e-07	, A8 = -1.66	619e-09		_	NA Magnification Focal length Image height (mm)	0.59 -3.51 3.49 10.82
						65	fb (mm) (in air) Lens total length (mm) (in air)	3.15 87.44
k = 0.360								

	Unit mm					5	9th surface		
	S	Surface data	a			_	k = 4.712		
rface no.	r	d	nd	vd	θgf	_	A4 = 2.70731e-07, A6 = 5.42517e-07, A8 = 10th surface	-1.96572e-10	
*	-51.987 34.312	5.12 0.50	1.85135	40.10	0.569	10	k = 0.590		
*	36.711	2.87	1.53366	55.96	0.555		A4 = 9.35359e-05, A6 = 8.42783e-08, A8 =	1.48700e-09	
*	-92.469	0.20					11th surface		
k	26.612	4.74	1.49700	81.61	0.538				
*	-11.451	0.05					k = 1.834		
t t	45.611	2.06	1.49700	81.61	0.538	15	A4 = 2.94251e-05, $A6 = -5.71155e-08$, $A8 = -6.71155e-08$	8.02874e-09	
k	-54.045 33.570	0.20 3.44	1.63484	23.91	0.622		12th surface		
k	-21.835	1.05	1.05-10-1	23.71	0.022				
*	-19.881	0.50	1.58360	30.33	0.591		k = -8.347		
(k	20.272	0.52					A4 = -9.71672e - 05, $A6 = 9.03846e - 09$, $A8 = -9.03846e - 09$	5.98733e-09	
	29.888	5.28	1.49700	81.61	0.538	•	17th surface		
	-9.919	0.50	1.72047	34.71	0.583	20			
(G))	2653.840	0.67					k = -0.493		
(Stop)	∞ 22.226	0.00	1.53366	55.00	0.555		A4 = -1.13272e-05, A6 = -1.77520e-07, A8	= 1.69868e-09	
k k	22.326	5.73	1.53366	55.96	0.555		18th surface		
ŧ	-48.583 -361.891	0.50	1.49700	Q1 <i>C</i> 1	0.529				
	-361.891 -14.580	3.71 0.81	1.72047	81.61 34.71	0.538 0.583	25	k = 0.000		
	-14.380 49.171	13.96	1.49700	81.61	0.538		A4 = 4.90449e - 05, $A6 = 8.80405e - 08$, $A8 = 3.80405e - 08$	2.05302e=12	
	-23.109	1.04	112/00	01.01	0.550		A4 = 4.90449e-03, A0 = 8.80403e-08, A8 = . 23th surface	2.03302 C -12	
8	34.641	3.26	1.84666	23.78	0.621		25th surface		
k	68.766	8.81	1101000	25.70	0.021		1 0040		
k	14.872	7.26	1.53366	55.96	0.555		k = -0.340		
8	-32.487	0.20				30	A4 = -4.99251e - 06, $A6 = -1.15596e - 07$, $A8$	= 5.65807e - 10	
*	24.860	4.91	1.53366	55.96	0.555		24th surface		
k	5.064	10.91							
t .	-6.358	3.04	1.53366	55.96	0.555		k = 0.000		
t .	-143.898	1.00					A4 = -2.71164e - 05, $A6 = -5.85984e - 08$, $A8$	= 5.28978e-10	
	∞	0.30	1.51633	64.14	0.535	35	25th surface		
1	∞	2.00							
age plane	8					_	k = -1.287		
	Asphe	rical surfac	ce data			_	A4 = -5.62805e - 05, $A6 = -7.66209e - 08$, $A8$	= -1.46489e-09	
1st surface						-	26th surface		
18t Stillace						_ 40	k = -28.138		
k = -2.324							A4 = -8.59208e - 06, $A6 = -1.62519e - 07$, $A8$	=-5.25099e-10	
A4 = -5.992	284e-04, A6 = -	2.07443e-	05, A8 = -5	.78774e-0)8		27th surface		
2nd surface									
							k = -11.343		
k = -45.725		7.550/1	07.40 :	42.67	00	45	A4 = -9.45284e-05, A6 = 8.98312e-07, A8 =	-3.28383e-09	
	295e-04, A6 = -	7.55261e-	07, A8 = -1	.43674e=(81		28th surface		
3rd surface						_			
k = -4.989							k = -1.166		
	46e-05, A6 = -3	22204=_0	7 AR = 1.53	980e=08			A4 = -2.25428e-04, A6 = 2.61901e-06, A8 =	-9,65650e-09	
$A4 = 1.330^2$ 4th surface	100-05, A0 = -5	.222V7C-V	,,no = 1.32	JUUC-U0		50	29th surface	2.000000	
rai sarrace						_ 50	25 di bulluoo		
k = 10.000							k = -0.771		
A4 = -1.198	884e-04, A6 = 7	.20040e-0	7, A8 = 1.57	561e-08			A4 = -1.76889e - 04, $A6 = 3.16654e - 06$, $A8 = 3.16654e - 06$	= -5 43037e=08	
5th surface							30th surface	- 3. -130370-00	
						_	John Surface		
1 2						55	lr = 0.000		
k = 2.681	65e-06, A6 = -6	.11721e-0	7, A8 = 7.66	294e-09			k = 0.000	2 27207- 00	
A4 = 5.7276						_	A4 = -3.96799e-04, A6 = 8.52970e-07, A8 =	= -2.373976-09	
						-	Various data		
A4 = 5.7276 6th surface							various data		
$A4 = 5.7276$ $\underline{6th \ surface}$ $k = -2.065$	71e-05 A6 = 61	4576e-07	A8 = 9 372	47e-09					
A4 = 5.7276 6th surface k = -2.065 A4 = 2.3717	71e-05, A6 = 6.1	:4576e-07	, A8 = 9.372	47e-09		60	27.4	0.00	
$A4 = 5.7276$ $\underline{6th \ surface}$ $k = -2.065$	71e-05, A6 = 6.1	14576e-07	, A8 = 9.372	47e-09		60	NA Mario di	0.62	
A4 = 5.7276 6th surface k = -2.065 A4 = 2.3717	71e-05, A6 = 6.1	14576e-07	, A8 = 9.372	47e-09		60	Magnification	-3.55	
A4 = 5.7276 6th surface k = -2.065 A4 = 2.3717 7th surface k = 8.756	71e-05, A6 = 6.1 464e-05, A6 = -)	60	Magnification Focal length	-3.55 3.98	
A4 = 5.7276 6th surface k = -2.065 A4 = 2.3717 7th surface k = 8.756)	60 -	Magnification Focal length Image height (mm)	-3.55 3.98 11.04	
A4 = 5.7276 6th surface k = -2.065 A4 = 2.3717 7th surface k = 8.756 A4 = -2.944)	- ⁶⁰	Magnification Focal length	-3.55 3.98	

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Unit mm						- 5	10th surface				
		Surface dat	9			-	k = -9.975				
rface no.	r	d	nd	νd	θgf	-	A4 = -1.06112e - 04, $A6 = 2.1015th surface$	0535e=01	7, A8 = 3.08	727e-09	
*	-33.708	5.42	1.85135	40.10	0.569	- 10	k = -0.105 A4 = -1.01308e-05, A6 = -9.9	94355e-(08 A8 = 24	.6319e_09	
*	30.549 32.705	0.05 3.04	1.53366	55.96	0.555		16th surface	J -1 3330-1	56, A6 = 2.4	05176-07	
8	-33.718	0.05	1.55500	33.90	0.555						
ķ	30.277	5.37	1.49700	81.61	0.538		k = -9.295 A4 = 5.21616e-05, A6 = 2.677	71.45 07	40 - 0 222	27- 10	
*	-9.108	1.92					A4 = 3.21010e - 03, $A0 = 2.07$.	/146-0/,	Ao = 0.322	276-10	
t t	30.171 -20.083	4.74 0.50	1.63484	23.91	0.622	15					
k	-21.758	0.50	1.58360	30.33	0.591		k = -0.825				
*	20.217	0.31					A4 = -4.71738e - 06, $A6 = -1.32$	19133e-0	07, A8 = 6.3	3286e-10	
	22.752	5.35	1.49700	81.61	0.538		22th surface				
	-11.085 109.760	0.50 1.33	1.72047	34.71	0.583		k = -9.836				
(Stop)	109.760 ∞	-1.02				20	A4 = -2.62975e - 05, A6 = -4.4	49742e-0	08, A8 = 5.5	0 344e-1 0	
k	19.480	3.80	1.53366	55.96	0.555		23th surface				
k	-36.243	0.50					k = -1.187				
	-46.615	2.73 1.29	1.49700 1.72047	81.61 34.71	0.538 0.583		A4 = -5.59393e - 05, A6 = -2.5	19981e-0	07, A8 = -1	.27378e-0	9
	-13.271 63.152	10.17	1.49700	81.61	0.538		24th surface				
	-21.328	5.57	1.15700	01.01	0.000	25	k = -9.425				
ŧ.	33.223	2.86	1.84666	23.78	0.621		A4 = -3.47590e - 06, $A6 = -2.1$	14126e_(07 A84	68874e_1	n
*	62.274	10.12	1.52266	55.06	0.555		25th surface	141200	07,210 - T	.000740 1	0
*	13.399 -44.297	6.98 0.10	1.53366	55.96	0.555						
k	23.820	4.79	1.53366	55.96	0.555		k = -10.000	1267 00	7 40 40	6057 00	
tr.	5.404	10.39				30	A4 = -9.66569e - 05, $A6 = 9.7326th surface$	1367e-0	/, A8 = -4.2	.6857e=09	
*	-5.660	2.59	1.53366	55.96	0.555	50	20th stillace				
ŧ	-57.346 ∞	1.00 0.30	1.51633	64.14	0.535		k = -1.038				
	∞ ∞	1.99	1.51055	07.17	0.555		A4 = -1.80783e - 04, $A6 = 9.34$	4922e-01	7, A8 = -2.7	3424e-09	
age plane	∞						27th surface				
Aspherical surface data				35	k = -0.796			673 00			
1st surface	Aspho	erical surfa	Je data			- -	A4 = 2.33856e-05, A6 = 1.107 28th surface	760e–06,	A8 = -4.51	672e-U8	
k = -2.324 A4 = -5.992	Aspho 284e-04, A6 = -			.78774e-(08	- 40	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54	4558e-0°	7, A8 = -1.5		
k = -2.324 A4 = -5.992 2nd surface				.78774e–(8(- -	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54		7, A8 = -1.5	8646e-09	
k = -2.324 $A4 = -5.992$ $2nd surface$ $k = -8.453$		-2.07443e-	05, A8 = -5			- -	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var	4558e-0°	7, A8 = -1.5	8646e-09	
k = -2.324 $A4 = -5.992$ $2nd surface$ $k = -8.453$	284e-04, A6 = -	-2.07443e-	05, A8 = -5			- -	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification	4558e-0°	7, A8 = -1.5	0.60 -3.53	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface	284e-04, A6 = - 218e-04, A6 = -	-2.07443e-	05, A8 = -5			_ _ 40 _	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var	4558e-0°	7, A8 = -1.5	8646e-09	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000	284e-04, A6 = - 218e-04, A6 = -	-2.07443e- -6.21190e-	05, A8 = -5 07, A8 = -3	.79375e-(09	- -	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air)	4558e–0°	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = -	-2.07443e- -6.21190e-	05, A8 = -5 07, A8 = -3	.79375e-(09	_ _ 40 _	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm)	4558e–0°	7, A8 = -1.5	0.60 -3.53 3.86 11.04	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = -	-2.07443e- -6.21190e-	05, A8 = -5 07, A8 = -3	.79375e-(09	_ _ 40 _	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air)	4558e–0°	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.066 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e-	05, A8 = -5 07, A8 = -3 07, A8 = 1.2	.79375e-(21769e-08	09	_ _ 40 _	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm)	4558e-0' rious data	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.066 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e-	05, A8 = -5 07, A8 = -3 07, A8 = 1.2	.79375e-(21769e-08	09	_ _ 40 _	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm)	4558e–0°	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.506 5th surface	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e-	05, A8 = -5 07, A8 = -3 07, A8 = 1.2	.79375e-(21769e-08	09	- 40 - 45	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm)	4558e-0' rious data	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.505 5th surface k = 0.977	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39	.79375e-(.1769e-08	3	- 40 - 45	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm)	4558e-0' rious data	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.505 5th surface k = 0.977	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39	.79375e-(.1769e-08	3	- 40 - 45	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa	4558e-07 rious data (in air)	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.509 5th surface k = 0.977 A4 = -1.410	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39	.79375e-(.1769e-08	3	- 40 - 45	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa	4558e-0' rious data (in air) ample 7	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.509 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0	.79375e-(21769e-08 0565e-08	3	- 40 - 45	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa	4558e-07 rious data (in air)	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.509 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0	.79375e-(21769e-08 0565e-08	3	40 45 50	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa	4558e-0' rious data (in air) ample 7	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.505 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674 A4 = -1.615 7th surface	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0	.79375e-(21769e-08 0565e-08	3	40 45 50	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa U Sur	4558e-07 rious data (in air) Ample 7 Unit mm rface data	7, A8 = -1.5 a	0.60 -3.53 3.86 11.04 3.18 93.13	θε
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.063 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.503 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674 A4 = -1.619 7th surface k = 4.822	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = - 254e-06, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0 -7.40956e- 3.89543e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0	21769e-08 2565e-08 2565e-09	3	40 45 50	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa	4558e-07 rious data (in air) ample 7 Unit mm	7, A8 = -1.5	0.60 -3.53 3.86 11.04 3.18 93.13	θε
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.066 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.509 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674 A4 = -1.619 7th surface k = 4.822 A4 = -3.063	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0 -7.40956e- 3.89543e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0	21769e-08 2565e-08 2565e-09	3	40 45 50 55	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa U Sur urface no. r 1* -36.181	4558e-0' rious data (in air) Juit mm rface data d 28.58	7, A8 = -1.5 a	0.60 -3.53 3.86 11.04 3.18 93.13	θ _ξ
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.066 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.505 5th surface k = 0.977 A4 = -1.416 6th surface k = -1.674 A4 = -1.616 7th surface k = 4.822	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = - 254e-06, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0 -7.40956e- 3.89543e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0	21769e-08 2565e-08 2565e-09	3	40 45 50	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Van NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa U Sur urface no. r 1* -36.181 2* -56.946 3* 61.405 4* -75.609	4558e-0′ rious data (in air) Unit mm rface data d 28.58 0.76 21.75 1.28	7, A8 = -1.5 a 72 nd 1.53368 1.63490	0.60 -3.53 3.86 11.04 3.18 93.13	θ _ξ 0.5 0.6
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.066 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.509 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674 A4 = -1.619 7th surface k = 4.822 A4 = -3.063	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = - 254e-06, A6 = -	-2.07443e- -6.21190e- -4.72804e- 4.21290e-0 -7.40956e- 3.89543e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0	21769e-08 2565e-08 2565e-09	3	40 45 50 55	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Van NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa U Sur urface no. r 1*	4558e-07 rious data (in air) Juit mm rface data d 28.58 0.76 21.75 1.28 13.63	7, A8 = -1.5 a 72 10 11 11 11 12	0.60 -3.53 3.86 11.04 3.18 93.13 vd	
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.066 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.505 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674 A4 = -1.619 7th surface k = 4.822 A4 = -3.066 8th surface k = 0.187	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = - 254e-06, A6 = -	-2.07443e6.21190e4.72804e- 4.21290e-0 -7.40956e- 3.89543e-0 5.40103e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0 7, A8 = 9.27	21769e-08 2565e-08 2571e-09 2075e-09	3	40 45 50 55	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Var NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa U Sur urface no. r 1*	4558e-0′ rious data (in air) Juit mm rface data d 28.58 0.76 21.75 1.28 13.63 0.05	7, A8 = -1.5 a nd 1.53368 1.63490 1.49700	0.60 -3.53 3.86 11.04 3.18 93.13 vd 55.90 23.88 81.61	θ _ξ 0.5 0.6 0.5
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.066 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.505 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674 A4 = -1.619 7th surface k = 4.822 A4 = -3.066 8th surface k = 0.187	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = - 254e-06, A6 = - 292e-06, A6 = 5	-2.07443e6.21190e4.72804e- 4.21290e-0 -7.40956e- 3.89543e-0 5.40103e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0 7, A8 = 9.27	21769e-08 2565e-08 2571e-09 2075e-09	3	40 45 50 55	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Van NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa U Sur urface no. r 1*	4558e-07 rious data (in air) Juit mm rface data d 28.58 0.76 21.75 1.28 13.63	7, A8 = -1.5 a 72 nd 1.53368 1.63490	0.60 -3.53 3.86 11.04 3.18 93.13	θ _ξ 0.5 0.6
k = -2.324 A4 = -5.992 2nd surface k = -8.453 A4 = -3.062 3rd surface k = -10.000 A4 = -2.322 4th surface k = 9.824 A4 = -9.505 5th surface k = 0.977 A4 = -1.410 6th surface k = -1.674 A4 = -1.615 7th surface k = 4.822 A4 = -3.062 8th surface k = 0.187 A4 = 1.0492	284e-04, A6 = - 218e-04, A6 = - 237e-05, A6 = - 229e-05, A6 = - 254e-06, A6 = - 292e-06, A6 = 5	-2.07443e6.21190e4.72804e- 4.21290e-0 -7.40956e- 3.89543e-0 5.40103e-0	05, A8 = -5 07, A8 = -3 07, A8 = 1.2 7, A8 = 1.39 07, A8 = 9.0 7, A8 = 9.27	21769e-08 2565e-08 2571e-09 2075e-09	3	40 45 50 55	A4 = 2.33856e-05, A6 = 1.107 28th surface k = 0.564 A4 = -3.12661e-04, A6 = 2.54 Van NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (mm) Exa U Sur 1* -36.181 2* -56.946 3* 61.405 4* -75.609 5* 31.784 6* -109.442 7 -131.758	4558e-0' rious data (in air) Juit mm rface data d 28.58 0.76 21.75 1.28 13.63 0.05 11.91	7, A8 = -1.5 a 122 a nd 1.53368 1.63490 1.49700 1.61800	vd 55.90 23.88 81.61 63.33	θ _ξ 0.5 0.6 0.5 0.5

221 -continued

222 -continued

-continued								-0	continue	ed		
		Unit mm				-			Unit mm			
	62.232	13.45	1.61800	63.33	0.544	- 5	22th sur	face				
*	-92.209 55.068 -67.262	2.29 22.12 34.05	1.49700	81.61	0.538	3		.12247e-06, A6 = -	1.43359e-	-09, A8 = -6	.54554e-1	12
*	-33.410 -66.553	0.69 65.37	1.58364	30.30	0.599		23th sur	face				
re re	-110.319 -70.789	24.35 9.27	1.63490	23.88	0.630	10		.88824e-05, A6 = 1.	.68813e=0	97, A8 = -5.7	7452e-10),
rk rk	28.392 -885.222	16.92 0.49	1.53368	55.90	0.563		A10 = 7.	.15614e-12				
rk rk	189.555 11.316	21.44 18.40	1.53368	55.90	0.563				/arious da	a		
	& &	0.30 0.07	1.51640	65.06	0.535	15	N	NA Magnification			0.81 -3.56	
age plane	∞					_	I	Focal length mage height (mm)			23.68 7.93	
	Asph	erical surfa	ce data			_		b (mm) (in air) Lens total length (mr	n) (in air)		18.67 316.53	
1st surface	e					_						
k = -173.7 $A4 = -3.3$ $2nd surface$	5526e-04, A6 =	1.26109e-0	05, A8 = -3.2	73711e-0°	7	20		Ех	kample '	73		
k = 5.924 A4 = -1.6	8456e-05, A6 =	1 61406e-0)8 A8 = −3 1	3890e-1	1	_	-					
3rd surfac		1.01 1000				_ 25			Unit mm			
	5538e-07, A6 =	1.17469e-0	99, A8 = -2.1	2993e-1	3				urface dat		,	0.6
4th surfac	e					-	Surface no.	r	d	nd	νd	θgf
	950e-07, $A6 = 2$.	.28598e-09	9, A8 = -1.15	5413e-12		30	1* 2* 3*	-40.282 463.655 -56.383	4.79 0.15 3.04	1.58364 1.53368	30.30 55.90	0.599
5th surfac	e					_	4*	-22.798	0.05			
	2987e-06, A6 =	-7.65103e-	-10, A8 = -7	.52953e-	14		5* 6* 7*	52.768 -30.496 99.502	3.31 0.05 4.30	1.53368 1.53368	55.90 55.90	0.563
6th surfac	<u>e</u>					_ 35	8* 9*	-15.870	0.05			
	55736e-06, A6 =	-2.85490e-	-10, A8 = 1.2	21681e-1	2		10* 11*	55.361 -40.687 -41.002	2.56 0.05 0.70	1.53368 1.58364	55.90 30.30	0.563
14th surfa	ce					-	12*	-132.635	0.05	1.36304	30.30	0.399
k = -0.859	9 0335e-06, A6 = -	2 257184	10 48 - 13	20520a 1	3	40	13* 14*	-197.895 -19.020	2.52 0.05	1.63490	23.88	0.630
A4 = -1.1 15th surfa	/	-2.23/106-	-10, Ao = 1	003296-1.	3		15*	-24.922	0.70	1.58364	30.30	0.599
						_	16*	37.592	0.05			
k = 0.165	022 00 46	C 71202 - 1	0.40.200	261- 12			17 18	32.596 -15.766	6.26 0.70	1.49700 1.72047	81.61 34.71	0.538 0.583
16th surfa	032e-08, A6 = -	0./13936-1	.0, Ao = 2.00)301e-13			19	-483.885	0.76	1.72047	54.71	0.565
1 our burn						- 45	20(Stop)	œ	-0.00			
k = -0.459							21*	31.326	1.93	1.53368	55.90	0.563
	377e-06, $A6 = -3$	3.03724e-0	9, A8 = 9.29	9938e-13			22*	336.567	0.43	1 40700	01 61	0.529
17th surfa	ce					_	23 24	129.510 -16.383	5.53 0.69	1.49700 1.72047	81.61 34.71	0.538 0.583
k = -4.24	7						25	44.942	5.29	1.49700	81.61	0.538
	051e-06, A6 = -4	4.82179e=0	9, A8 = 1.61	7011e-12		50		-28.775	10.44	1,,,,,,,	01.01	0.000
18th surfa			, 1.0				27*	43.477	3.20	1.84666	23.78	0.620
						_	28*	108.100	8.65			
k = -63.9					_		29*	13.858	7.47	1.53368	55.90	0.563
	636e-06, $A6 = -3$	3.87038e-0	9, A8 = -3.4	18009e-1	3,		30* 31*	-48.612	1.07	1 52269	55.00	0.562
	77701e-15						31*	26.460 4.837	6.21 7.57	1.53368	55.90	0.563
19th surfa	ce					_ 55	33*	-354.887	1.05	1.53368	55.90	0.563
k = -1.37	7						34*	-13.673	1.18	1.55500	55.50	0.505
	7891e-07, A6 = 1	1.15104e-1	0. A8 = -1	16999e_1	2.		35*	-10.332	1.47	1.53368	55.90	0.563
A4 = -0.4 A10 = 1.5		1.1010 +6 -1	, 2 101.2	. 07775-1.	-,		36*	10.221	2.00			
20th surfa							37	∞	0.30	1.51640	65.06	0.535
						60	38 Image plane	& &	1.07			
k = -1.324 A4 = -3.2	4 27595e-06, A6 = 3	5.51173e-0)9, A8 = -9.4	15068e-1	3,			Asphe	rical surfa	ce data		
A10 = 5.2								Asplie	vai ouita	oc uana		
21th surfa	ce					_	1st surfa	ce				
							-					

k = -1.000

A4 = 5.09843e-07, A6 = -7.59988e-10, A8 = -3.15984e-12

 $\begin{array}{l} k = -3.208 \\ A4 = -4.00276 \\ e^{-04}, A6 = -1.07790 \\ e^{-05}, A8 = -1.87287 \\ e^{-08} \end{array}$

	. •	1
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Unit mm				Unit mm			
2nd surface	<u> </u>	29th surfa	ce				
k = 7.798 A4 = -2.75758e-04, A6 = 2.10308e-08, A8 = -1.33321e-08 3rd surface	_	k = -1.42 $A4 = -4.4$ $30th surfa$	4964e-05, A6 = -	1.14731e-	-07, A8 = -1	.32031e-0)9
k = -18.910 A4 = -2.56423e-05, A6 = 8.98086e-08, A8 = -7.50836e-10 4th surface	10	k = -49.5 A4 = -3.5 31th surfa	8778e-06, A6 = -	1.51652e-	-07, A8 = -4	.21497e-1	.0
$\label{eq:k} \begin{array}{l} k = 4.218 \\ A4 = -8.97703 e{-05}, A6 = 6.34630 e{-09}, A8 = 1.59473 e{-10} \\ 5th surface \end{array}$		k = -11.0 $A4 = -4.0$ $32th surfa$	01806e-05, A6 = 5	.78536e-0	97, A8 = -3.8	3048e-09)
k = 2.825 A4 = 4.35005e-06, A6 = -3.43208e-07, A8 = 1.63947e-09 6th surface		k = -1.06 A4 = -5.1 33th surfa	4012e-05, $A6 = 3$.96589e-0	06, A8 = 5.12	675e-10	
k = -1.000 A4 = -2.56460e-06, A6 = 2.06882e-08, A8 = 5.97876e-10 7th surface	20	k = -84.74 $A4 = -9.3$ 34 th surfa	9725e-05, A6 = 2	.40683e-0	06, A8 = 1.83	664e-08	
k = -1.000 A4 = -3.77951e-06, A6 = -6.33826e-09, A8 = 6.94696e-10 8th surface		k = -19.3 A4 = 3.43 35th surfa	366e-04, $A6 = 1.7$	79039e-06	$A_{5}, A_{8} = -6.69$	090e-09	
$\begin{array}{l} k = -1.945 \\ A4 = 3.71988e - 06, A6 = -6.66431e - 08, A8 = 2.51358e - 09 \\ 9th \ surface \end{array}$	25	k = -5.30 A4 = 2.75 36th surfa	881e-04, $A6 = 2.5$	51333e-07	, A8 = 1.186	69e-08	
$\begin{array}{l} k = -18.446 \\ A4 = -4.05634 \\ e-05, A6 = -2.46856 \\ e-07, A8 = 2.65735 \\ e-09 \\ 10 \\ th \ surface \end{array}$	30	k = -14.5 A4 = -1.7	72642e-04, A6 = 1		·	9913e-08	;
k = -1.000				Various da	ta		
A4 = 1.06948e-06, A6 = 9.57333e-09, A8 = 3.53159e-11 11th surface			agnification			0.80 -3.54	
k = -1.000 A4 = 9.00548e-08, A6 = 1.08965e-08, A8 = 2.56428e-11 12th surface	35	Im fb	cal length nage height (mm) (mm) (in air) ens total length (mi	m) (in air)		3.60 7.39 3.27 94.87	
$\begin{array}{l} k = -25.185 \\ A4 = 1.20782e{-}05, A6 = 3.66535e{-}07, A8 = -1.92641e{-}09 \\ 13th \ surface \end{array}$	40		E:	xample '	74		
$\begin{array}{l} k = 9.934 \\ A4 = -5.58480 \\ e^{-06}, A6 = 3.40383 \\ e^{-07}, A8 = -7.89811 \\ e^{-10} \\ 14 \\ th \ surface \end{array}$				T.T14			
k = 0.011	45	Unit mm Surface data					
A4 = 6.84867e-05, A6 = 2.15623e-08, A8 = 3.28107e-09 15th surface		Surface no.	r	d	nd	vd	θgf
k = 2.072 A4 = 1.58083e-05, A6 = 1.06906e-07, A8 = 3.45403e-09		1* 2*	-22.220 -110.607	11.55 0.80	1.53368	55.90	0.563
16th surface	50	3* 4*	69.374 -55.648	9.96 11.12	1.84666	23.77	0.620
k = -5.656 A4 = -8.90526e - 05, $A6 = -2.43611e - 07$, $A8 = 1.71510e - 0921th surface$		5* 6* 7*	-53.462 -1333.696 41.975	3.04 0.30 11.11	1.58364 1.49700	30.30 81.61	0.599 0.538
k = 0.012 A4 = -4.60350e-06, A6 = -1.00301e-07, A8 = 1.22359e-09 22th surface	55	8* 9 10 11 12(Stop)	-33.586 -93.239 -21.843 39.981 ∞	6.66 5.38 1.00 13.59 1.53	1.61800 1.72047	63.33 34.71	0.544 0.583
k = -1157.205 A4 = 2.04437e-05, A6 = 1.78478e-07, A8 = 1.96410e-10 27th surface	60	13 14 15 16*	-61.889 50.762 -54.934 59.467	1.00 5.24 0.10 7.14	1.72047 1.61800 1.49700	34.71 63.33 81.61	0.583 0.544 0.538
k = 0.320 A4 = -1.89280e-06, $A6 = -5.83570e-08$, $A8 = 1.95523e-1028th surface$		17* 18* 19*	-66.460 82.096 -54.564	0.10 7.55 3.09	1.49700	81.61	0.538
k = -177.199 A4 = -1.76597e-05, A6 = -2.74436e-08, A8 = 1.63913e-10	65	20* 21* 22* 23*	-64.204 444.592 71.214 -83.225	3.00 8.67 10.98 28.34	1.58364 1.63490	30.30 23.88	0.599

225		226						
-continued		_	-continued					
Unit mm					Unit mm			
-67.867 6.01 1.53368 55.90 -608.925 5.07	0.563	5	24th surfac	ce				
-29.940 1.00 1.53368 55.90	0.563		k = -2.311					
92.925 5.00 ∞ 0.30 1.51640 65.06	0.535		A4 = -2.4	1567e-05, $A6 = 2$.	27044e-0	8, A8 = -4.2	8423e-11	Ι,
∞ 6.50 ge plane ∞			A10 = -3.4 25th surfac	47983e-14 ce				
Aspherical surface data		10		<u> </u>				
			k = 0.000 A4 = -4.10	0895e-06, A6 = -3	3.67106e-	09, A8 = -4.	.04819e-1	11,
1st surface		•		16188e-17				
k = -3.559 A4 = 7.43178e-07, A6 = 9.21714e-09, A8 = 5.34633e-12		15	26th surfac	:e				
2nd surface		. 13	k = 0.000					
k = -56.705			A4 = -1.1 A10 = 2.40	1631e-06, A6 = 8.	03468e-0	9, A8 = -1.0	8760e-11	Ι,
A4 = 1.26171e - 05, A6 = -2.11058e - 08, A8 = 1.11767e - 1	1		A10 = 2.40 27th surface					
3rd surface		20						
k = -0.891 A4 = -4.74513e-07, $A6 = -1.03632e-10$, $A8 = 4.27759e-$.13		k = -33.62	!3 6905e-05, A6 = 4.	78713e_0	8 A875	5486e_11	ı
4th surface		•	A10 = 4.72	*	707130	0,710 - 7.3	J-000 11	,
k = -2.005		-		7.	arious dat			
A4 = -2.95949e-07, $A6 = 1.71592e-09$, $A8 = -1.02814e-5$ th surface	12	25 _		v	arious dat	а		
		•	NA				0.23	
k = 0.000 A4 = 1.12076e-06, A6 = -3.15698e-09, A8 = -9.10021e-12			-	iification length			-1.33 23.92	
6th surface				e height(mm)			21.63	
k = 0.000		30	_	n) (in air)			11.70	
A4 = -1.68052e - 06, $A6 = -2.21792e - 10$, $A8 = -7.11388e$ 7th surface	: −12	_	Lens	total length(mm) (in air)		175.01	
k = -2.402 A4 = -2.97163e-07, A6 = -2.14703e-09, A8 = 5.48901e-8th surface	-12	35		Ex	kample '	75		
k = -3.764 A4 = -7.20305e-07, A6 = -1.04316e-09, A8 = 3.58089e- 16th surface	·12	_						
k = -0.278		40			Unit mm			
A4 = 9.99889e-07, $A6 = -1.23318e-09$, $A8 = -5.26020e-17$ th surface	13	Surface data						
k = -0.949		_	Surface no.	r	d	nd	νd	θ
A4 = 6.09329e - 08, A6 = -2.45917e - 10, A8 = 8.84736e - 1	6		1* 2*	-18.167 -6801.076	3.69 0.08	1.53368	55.90	0.5
18th surface		. 45	3*	21.678	6.12	1.84666	23.77	0.6
k = 3.430			4* 5*	-284.362 12.760	0.36 5.89	1.49700	81.61	0.5
A4 = 2.90794e-08, A6 = 5.65189e-10, A8 = -6.39630e-1	6		6*	-83.302	2.65	1.15700	01.01	0.0
19th surface		•	7	-13.598	1.64	1.59522	67.74	0.5
k = -2.160		50	8 9	-8.480 110.487	0.70 4.96	1.72047	34.71	0.5
A4 = -3.62571e - 07, $A6 = -3.42492e - 09$, $A8 = -3.01979e$:-13	1	0(Stop)	∞	0.80		_	
20th surface			.1	-48.292	0.70	1.72047	34.71	0.5
k = -0.380			.2	19.168 -22.873	3.57 0.05	1.61800	63.33	0.5
A4 = 9.15647e - 07, $A6 = -7.30470e - 09$, $A8 = -7.03078e -$	13	1	4*	28.235	4.20	1.49700	81.61	0.5
21th surface			.5* .6*	-20.667 30.523	0.05 4.86	1.49700	81.61	0.5
k = 0.000			.7*	-26.992	2.22	1.42/00	01.01	0.3
A4 = 1.54086e-06, A6 = 1.31932e-09, A8 = 6.29723e-16		1	8*	-43.570	1.92	1.58364	30.30	0.5
22th surface			.9* !0*	28.439 37.236	3.33 3.81	1.63490	23.88	0.6
		2	:0* !1*	-37.308	12.91	1.03490	23.00	0.0
-			2*	-11.417	0.70	1.53368	55.90	0.5
k = -8.393				-54.620	3.52			0.5
k = -8.393 A4 = 1.48279e-07, A6 = 1.47956e-10, A8 = 2.41697e-13	,	2	23*		1.00	1 52260	5E 00	
k = -8.393	,	2	!4*	-15.141	1.00 1.42	1.53368	55.90	0.5
k = -8.393 A4 = 1.48279e-07, A6 = 1.47956e-10, A8 = 2.41697e-13 A10 = -4.40436e-16 23th surface	,	. 2 . 2 . 2	!4* !5* !6		1.42 0.30	1.53368 1.51640	55.90 65.06	0.5
k = -8.393 A4 = 1.48279e-07, A6 = 1.47956e-10, A8 = 2.41697e-13 A10 = -4.40436e-16		. 2	14* 15*	-15.141 52.853	1.42			

Unit mm Aspherical surface data				Unit mm			
		Various data					
1st surface							
k = -4.386 A4 = 8.13964e-05 2nd surface	10	NA Magnifi Focal le Image l				0.23 -1.33 8.65 10.82	
k = -48.345 A4 = -1.43933e-04, A6 = -8.00000e-08 3rd surface		fb(mm) Lens to	(in air) tal length(mm	i) (in air)		2.12 71.86	
k = -0.148 A4 = 2.62435e-05, A6 = 7.46587e-08 4th surface	15		Ех	kample '	76		
k = -2.471 A4 = 1.13156e-04, A6 = -3.03432e-07 5th surface							
k = 0.000	20			Unit mm			
A4 = -3.28501e-05 6th surface	_		S	urface dat	a		
		Surface no.	r	d	nd	νd	$\theta g f$
k = 0.000 A4 = 1.86975e-04, A6 = 1.18474e-06 14th surface	25	1* 2*	-6.594 -15.141	2.71 0.05	1.53368	55.90	0.563
k = -0.451		3* 4*	22.089 -18.712	3.91 2.70	1.84666	23.77	0.620
A4 = -7.69062e - 06, $A6 = -1.43734e - 0815th surface$		5* 6*	-17.254 34.657	1.10 0.11	1.58364	30.30	0.599
	30	7* 8*	12.140 -10.668	3.83 1.93	1.49700	81.61	0.538
k = -1.249 A4 = 2.02493e-05, A6 = 4.19132e-09	30	9	-37.991	1.88	1.61800	63.33	0.544
16th surface		10 11	-6.858 12.533	0.70 3.26	1.72047	34.71	0.583
k = 0.000 A4 = -8.45589e-06, A6 = 8.20795e-08 17th surface		12(Stop) 13	∞ -25.651	0.31 0.70	1.72047	34.71	0.583
	35	14	12.946	2.21	1.61800	63.33	0.544
		15 16*	-21.372 25.619	0.05 3.07	1.49700	81.61	0.538
k = -1.911 A4 = -3.58629e-05, A6 = 5.27389e-08		17*	-16.426	0.05			
A4 = -3.380296 - 03, $A0 = 3.273896 - 0818th surface$		18* 19*	23.987 -18.969	3.45 0.05	1.49700	81.61	0.538
k = -0.212	40	20* 21*	-67.273 23.516	1.10 0.82	1.58364	30.30	0.599
A4 = -6.84952e-05, A6 = -5.77815e-08		22*	23.296	3.10	1.63490	23.88	0.630
19th surface		23* 24*	-29.511 -16.767	11.11 0.50	1.53368	55.90	0.563
k = 0.000		25* 26*	-22.808 -7.454	1.74 0.50	1.53368	55.90	0.563
A4 = -4.80004e - 05, $A6 = -6.13427e - 0820th surface$	45	27*	39.382	2.00			
		28 29	& &	0.40 2.09	1.51640	65.06	0.535
k = -6.911 A4 = 3.04669e-05, A6 = -1.68754e-07		Image plane	œ	2.32			
21th surface			Asphei	rical surfa	ce data		
k = 0.000	50 -	1st surface					
A4 = 1.99883e-06, A6 = -1.14266e-08 22th surface		k = -3.337 A4 = 7.81336e	-05, A6 = 7.2	6382e-07	, A8 = 2.768	889e-08	
k = 0.000 A4 = -3.55672e-05, A6 = 1.28738e-06 23th surface	55	2nd surface k = -12.283 A4 = 1.65761e	-04, A6 = -4.	78004e-0	06, A8 = 1.77	7405e-08	
k = 0.000 A4 = 7.71680e-05 24th surface		$\frac{3\text{rd surface}}{k = -0.001}$ $A4 = 2.82582e$	-06, A6 = 6.4	0852e-09	9, A8 = 4.337	750e-09	
k = 0.000 A4 = 1.41483e-04, A6 = 1.00000e-07 25th surface		4th surface k = -3.772 A4 = 3.75820e	-05, A6 = 3.8	1325e-07	', A8 = −1.37	7171e-09	
k = -200.000 A4 = -1.00622e-04, A6 = -2.32970e-07	65	5th surface k = 0.000	05.46.1	70570- (06, A8 = -1.3	26696 06	

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Unit mm							
6th surface				Unit mm			
k = 0.000				Surface da	ta		
A4 = -5.68162e-05, A6 = -5.39505e-07, A8 = -3.46650e-0 7th surface		Surface no.	r	d	nd	νd	θgi
k = -2.416 A4 = -3.38395e-05, A6 = -3.57963e-07, A8 = 2.59868e-08	10	1* 2*	-5.961 -24.609	2.31 0.05	1.53368	55.90	0.56
8th surface		3* 4*	17.837 -14.424	2.80 1.82	1.84666	23.77	0.62
k = -4.028 A4 = 2.66890e-05, A6 = 7.32902e-07, A8 = 2.65023e-08 16th surface		5* 6*	-15.035 3512.460	0.46 0.05	1.58364	30.30	0.59
k = -0.019	15	7* 8* 9	9.702 -7.673 -31.622	3.32 0.99 1.50	1.49700 1.61800	81.61 63.33	0.53
A4 = 8.97367e-05, A6 = -1.03233e-06, A8 = 7.72299e-09 17th surface		10 11	-5.784 9.829	0.70 3.18	1.72047	34.71	0.58
k = -1.855		12(Stop) 13	∞ -19.695	0.25 0.70	1.72047	34.71	0.58
A4 = 1.90242e-05, A6 = -6.72839e-07 18th surface	20	15	12.012 -12.780	1.60 0.05	1.61800	63.33	0.54
k = 0.000		16* 17*	18.475 -13.500	2.02 0.05	1.49700	81.61	0.53
A4 = 9.30171e-06, A6 = 3.12746e-07 19th surface	25	18* 19* 20*	11.482 -27.656 -13.626	2.43 0.49 0.52	1.49700 1.58364	81.61 30.30	0.53
k = -1.268	23	21* 22*	-361.234 16.895	1.85 1.87	1.63490	23.88	0.63
A4 = -1.75825e - 05, $A6 = -1.24240e - 07$, $A8 = 6.25523e - 0920th surface$		23* 24*	-23.260 -7.198	5.30 0.46	1.53368	55.90	0.56
k = 0.000 A4 = -2.42353e-06, A6 = -2.15990e-06, A8 = 7.78426e-09	30	25* 26* 27*	-10.330 -5.492 18.144	1.16 0.50	1.53368	55.90	0.56
21th surface		28 29	16.144 ∞ ∞	2.00 0.30 0.81	1.51640	65.06	0.53
k = 0.000 A4 = 2.55273e-05, A6 = -1.61257e-08 22th surface		Image plane	&	erical surfa	uce data		
22th surface	35		Aspin	ericai surra	ice data		
k = -7.622 A4 = -3.41674e-06, A6 = -3.51619e-08, A8 = 5.04095e-09, A10 = -4.72437e-11 23th surface		k = -3.978 $A4 = 6.83$		94032e-05	5, A8 = 1.334	54e-07	
k = 0.000 A4 = -8.30630e-05, A6 = 3.95126e-08, A8 = 3.41864e-09, A10 = -2.19047e-11 24th surface	40	2nd surfac k = -58.62 A4 = 7.539 3rd surface	26 903e-04, A6 = -2	2.26638e-(05, A8 = 1.17	000e-07	
k = 0.000 A4 = -6.73311e-04, A6 = 3.53688e-06, A8 = 6.26103e-08, A10 = -2.83370e-09 25th surface	45	k = -1.266	5 7500e-05, A6 = 0	6.78520e-(07, A8 = 4.37	879e-09	
k = -31.496 A4 = -2.03990e-04, A6 = -1.56737e-06, A8 = -7.81513e-08 26th surface	50	5th surface	194e-05, $A6 = 2$.	27427e-06	5, A8 = 9.949	44e-10	
k = 0.000 A4 = 4.15201e-04, A6 = -1.51111e-06, A8 = 1.73325e-09 27th surface		6th surface	950e-04, A6 = -3	1.46201e-0	06, A 8 = -1.0	05504e-07	•
k = -182.577 A4 = -7.13102e-04, A6 = 1.05027e-05, A8 = -1.26316e-07, A10 = -4.92836e-11		7th surface		-3.81661e-	-07, A8 = -1	.23805e-0)7
Various data	60	k = -1.950 $A4 = -9.75$ 8th surface	2173e-06, A6 = -	-4.81006e-	-06, A8 = 1.4	6505e-07	,
NA 0.23 Magnification -1.34 Focal length 7.83 Image height(mm) 7.46	00	k = -4.052	2 783e-05, A6 = 1.	17082e-06	5, A8 = 9.416	36e-08	
fb(mm) (in air) 4.36 Lens total length(mm) (in air) 55.30	65	k = -2.587 A4 = 7.94	7 127e-05, A6 = 2.	33251e-09	9, A8 = -2.69	891e-08	

-continued	-continued
commuca	commuca

-continued					commu	ca		
Unit mm					Unit mm	1		
17th surface			8*	-6.900	0.75			
		5	9	-25.846	1.61	1.61800	63.33	0
k = 0.444			10	-5.005	0.70	1.72047	34.71	0
A4 = -2.36239e - 05, $A6 = 3.53777e - 07$			11	8.524	2.75			
18th surface			12(Stop)	∞	0.24			
			13	-16.089	0.70	1.72047	34.71	0
k = 0.000			14	10.367	1.58	1.61800	63.33	0
A4 = 2.69183e - 05, $A6 = 7.42095e - 07$		10	15	-11.398	0.05			
19th surface			16*	14.113	1.91	1.49700	81.61	0
			17*	-13.179	0.05			
k = -0.016			18*	12.193	2.41	1.49700	81.61	0
A4 = -7.15117e - 05, $A6 = -3.49750e - 06$, $A6 = -3.49750e - 06$	8 = -9.15827e - 10		19*	-16.975	0.56			
20th surface			20*	-11.963	0.46	1.58364	30.30	0
		15	21*	-1533.737	1.63			
k = -1.384			22*	14.750	1.84	1.63490	23.88	0
A4 = 8.37580e-05, $A6 = -8.92246e-06$, $A8$	= 7.34778e-08		23*	-19.850	4.58			
21th surface			24*	-8.763	0.50	1.53368	55.90	C
			25*			1.55506	55.90	C
k = 0.000				-22.584	1.25	1 50055	55.00	
A4 = 5.59543e-05, A6 = -9.82470e-07			26*	-5.430	0.50	1.53368	55.90	0
22th surface		20	27*	17.171	1.00			
22th statute			28	∞	0.30	1.51640	65.06	C
k = -9.050			29	∞	1.30			
A4 = 2.70247e - 05, $A6 = 7.50428e - 07$, $A8 = 4.50428e - 07$	_7.24065e_08		Image plane	∞				
A10 = 1.48867e-10	-7.249036-06,							_
23th surface				Asphe	erical surfa	ace data		
25th stirlace		25		Topin		or data		
k = 0.000			1st surfac	re.				
A4 = -3.00084e - 05, $A6 = -9.41421e - 07$, $A6 = -9.41421e - 07$	9 _ 1 23690a 09		150 501100					
A4 = -3.000848 - 03, $A6 = -9.414218 - 07$, $A6 = -9.41418$, $A6 = -9.4148$, $A6 = -9.4148$, $A6 = -9.4148$, $A6 = -9.418$, $A6 = -9.4148$, $A6 = -9.4188$	o = -1.23000e-00,		1- 2.74	- 1				
			k = -3.75					
24th surface				3644e - 04, $A6 = 3.5$	51095e-0:	5, A8 = 3.763	571e-07	
1- 0.035		30	2nd surfa	ice				
k = -0.035	7.44597- 07	30						
A4 = -1.97646e-03, A6 = 3.98966e-05, A8	= -7.445866-07,		k = -52.9	983				
A10 = -1.49643e-08			A4 = 1.11	9282e-03, $A6 = -4$.36922e-0	95, A8 = 4.49	9809e-07	
25th surface			3rd surfa	ce				
k = 0.000								
A4 = 3.47230e - 05, $A6 = -6.91721e - 06$, $A8$	= -6 57343e-08	25	k = -1.02	23				
A4 = 5.472308 - 05, $A6 = -0.917218 - 06$, $A826th surface$		35	A4 = -4.	33927e-05, A6 = 1	.26681e-0	06, A8 = 1.69	9670e-08	
2001 5011400			4th surfa	,				
k = 0.000								
A4 = 3.62836e-06, A6 = 9.62479e-06, A8 =	-6.05415e-07		k = -2.86	52				
27th surface	5.05 1150-07			2430e-06, A6 = 4.4	43110e=0	6. A8 = -2.90)479e-08	
2 / di Saliace			5th surfa		1100 01	-,110 - 2100		
k = -77.408		40	<u> </u>	~				
A4 = -1.88100e - 03, $A6 = 3.52845e - 05$, $A8$	= -1.48363e-06		k = 0.000)				
A4 = -1.88100e-03, A6 = 3.32843e-03, A8 A10 = 1.10111e-08	1.403036-00,				90552	06 49 23	12104 05	,
A10 = 1.10111e-08				2796e-04, $A6 = -3$.80553e=0	36, A8 = -3.1	13184e-07	
Various data			6th surfa	ce				
ranous data			k = 0.000)				
NA	0.22	45		74059e-04, A6 = -	1 12245~	06 48 - 2	34062c (17
Magnification	-1.34				1.122436	-vu, Ao = -3	.J47026-(, ,
Focal length	5.46		7th surfa	ue .				
Image height(mm)	5.33		_					
fb(mm) (in air)	3.01		k = -2.01					
Lens total length(mm) (in air)	39.44		A4 = 1.5	2723e-05, $A6 = -8$.41101e-0	96, A8 = 3.66	5174e-07	
Lens total rength(mm) (m an)	J.J.TT	50	8th surfa	ce				
	<u> </u>	_ 00						
			k = -3.98	36				

Example 78

						33
		Unit mm				
	;	Surface dat	ta			
Surface no.	r	d	nd	νd	$\theta g f$	60
1*	-5.094	2.25	1.53368	55.90	0.563	_
2*	-21.978	0.05				
3*	14.759	2.61	1.84666	23.77	0.620	
4*	-12.484	1.35				
5*	-12.647	0.50	1.58364	30.30	0.599	
6*	-300.282	0.05				65
7*	8.853	2.98	1.49700	81.61	0.538	

		Unit mm			
8*	-6.900	0.75			
9	-25.846	1.61	1.61800	63.33	0.544
10	-5.005	0.70	1.72047	34.71	0.583
11	8.524	2.75			
12(Stop)	∞	0.24			
13	-16.089	0.70	1.72047	34.71	0.583
14	10.367	1.58	1.61800	63.33	0.544
15	-11.398	0.05			
16*	14.113	1.91	1.49700	81.61	0.538
17*	-13.179	0.05			
18*	12.193	2.41	1.49700	81.61	0.538
19*	-16.975	0.56			
20*	-11.963	0.46	1.58364	30.30	0.599
21*	-1533.737	1.63			
22*	14.750	1.84	1.63490	23.88	0.630
23*	-19.850	4.58			
24*	-8.763	0.50	1.53368	55.90	0.563
25*	-22.584	1.25			
26*	-5.430	0.50	1.53368	55.90	0.563
27*	17.171	1.00			
28	∞	0.30	1.51640	65.06	0.535
29	∞	1.30			
Image plane	∞	2.50			

Aspherical	curface	dat
Asbuericai	SHITIACE	uai

1st surface
k = -3.753 A4 = 1.53644e-04, A6 = 3.51095e-05, A8 = 3.76371e-07 2nd surface
2nd surface
$\begin{array}{l} k = -52.983 \\ A4 = 1.19282e - 03, A6 = -4.36922e - 05, A8 = 4.49809e - 07 \\ 3rd \ surface \end{array}$
k = -1.023 A4 = -4.33927e-05, A6 = 1.26681e-06, A8 = 1.69670e-08 4th surface
k = -2.862 A4 = 8.92430e-06, A6 = 4.43110e-06, A8 = -2.90479e-08

A6 = -8.41101e - 06, A8 = 3.66174e - 07

A4 = 8.69409e-06, A6 = 1.21957e-0 6, A8 = 2.32185e-0716th surface

k = -1.895

A4 = 1.310256-04, A6 = -4.142 91e-07, A8 = -1.11771e-07 17th surface k = -0.030A4 = 5.119896-06, A6 = 1.41228e-06 18th surface A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665

A4 = -9.13946e - 05, A6 = -9.02423e - 06, A8 = -1.32639e - 07

	-Co	ontinue	1					-co	ontinuec	i		
	1	Unit mm				•		Ţ	Jnit mm			
20th surfa	ce					• - 5	20*	13.192	3.44	1.58364	30.30	0.599
k = -0.869 $A4 = 9.86$ 21 th surfa	6704e-05, A6 = -1.	97220e-05	5, A8 = 3.108	396e-08		,	21* 22* 23* 24*	-15.080 -9.430 10.877 -10.747	3.70 0.81 2.39 0.51	1.49700 1.53368	81.61 55.90	0.538 0.563
k = 0.000 A4 = 1.09 22th surfa	340e-04, A6 = 1.74	1012e-06				10	25* 26 27 Image plane	−3339.876 ∞ ∞ ∞	1.75 0.38 0.50	1.51640	65.06	0.535
k = -7.88	1					_		Aspheri	cal surfac	e data		
A4 = 4.76	596e-05, A6 = 1.36 98830e-09	5921e-06,	A8 = -6.410	81e-08,		15		1st surface				
k = 0.000 $A4 = -1.1$	6502e-04, A6 = -1 23320e-09	.10099e-0	07, A8 = -1.3	4141e-08	3,	_ 10		k = 0.000 A4 = 1.00145e-05 2nd surface				
k = -0.003 $A4 = -2.6$ $A10 = -1$	3 9363e-03, A6 = 5.7 79590e-08	72972e-05	, A8 = -2.11	668e-06,		20		k = 0.000 A4 = 4.66734e-05 5th surface k = 0.699				
25 th surfa $ k = 0.000 $ $ A4 = -1.4$	9191e-04, A6 = -1	.19921e-0	95, A8 = -8.5	7893e-01	7	- 25		A4 = 2.24508e-05 8th surface				
$\frac{26\text{th surfa}}{\text{k} = 0.000}$	7594e-04, A6 = 1.1					-		k = 0.000 A4 = 8.05284e-05 16th surface k = -0.579				
k = -68.04	41 5930e-03, A6 = 7.9	91869e-05	, A8 = -3.96	242e-06,		- 30		A4 = 7.50799e-06 17th surface k = 0.000				
	V	arious data	ı			•		A4 = -8.03928e - 05 18th surface	;			
Fo Im	agnification cal length age height(mm)			0.23 -1.33 4.88 4.75		- 35		k = 0.000 A4 = 2.62042e-04 19th surface				
	(mm) (in air) ns total length(mm)	(in air)		2.50 36.35		4 0		k = 0.000 A4 = 2.02927e-08 20th surface				
	Ex	ample 7	9			45		k = 0.000 A4 = 1.22996e-05 21th surface				
	Ţ	Unit mm				•		k = 0.000 A4 = 1.31433e-04				
	Su	ırface data				•		22th surface				
Surface no.	r	d	nd	νd	$\theta \mathrm{gf}$	50		k = 0.000 A4 = 1.29005e-10				
1* 2*	29.347 -36.004	3.01 0.10	1.84666	23.77	0.620			23th surface				
3	-397.741 21.124	0.70 0.10	1.65412	39.68	0.574			k = 0.000 A4 = -8.96164e-11				
5*	19.426	4.27	1.49700	81.61	0.538	55		A4 = -8.96164e - 11 $24 th surface$	•			
6 7 8*	-31.982 20.342	0.10 3.53 0.10	1.49700	81.61	0.538			k = 0.000				
9	-22.961 -172.666	2.93	1.61800	63.33	0.544			A4 = 3.63415e-11 25th surface				
10 11 12(Stan)	-11.505 24.226	0.70 0.79	1.72047	34.71	0.583	60		k = 0.000				
12(Stop) 13	∞ -243.374	0.17 0.70	1.90366	31.32	0.595			A4 = -8.06302e - 04	4, A6 = -6	.85664e-06		
14 15	9.660 -43.351	3.41 0.10	1.61800	63.33	0.544			Va	rious data			
16* 17*	11.180 -10186.757	4.50 8.48	1.49700	81.61	0.538			NA			0.38	
18* 19*	719.997 13.006	0.70 6.32	1.49700	81.61	0.538	65	I	Magnification Focal length		-	-2.20 5.02	

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ued -continued

	-c	ontinue	ed					-0	continue	ed		
		Unit mm					Unit mm					
Imaa	ge height(mm)			4.92		 5	19	th surface				
fb(m	um) (in air) s total length(mm) (in air)		2.50 54.08		- -	A	= 0.000 1 = -1.11086e-0 th surface	4			
	Ex	ample	80			10	A	= 0.000 4 = -1.48114e-0 th surface	4			
		r					k =	= 0.000 4 = -8.65591e-0	4, A6 = -	1.95796e-05	i	
		Unit mm				 15		V	arious da	ta		
	S	urface dat	ta				NA				0.32	
a 6					0.6	-	Mag	nification			-2.00	
Surface no.	1 00 C	d	nd	vd 55.00	θgf	-	Imag	l length e height(mm)			3.72 3.87	
1 2*	-4.006 -5.643	2.23 0.10	1.53368	55.90	0.563	20		m) (in air) total length(mm) (in air)		1.60 39.40	
3*	25.874	2.62	1.84666	23.77	0.620	_	Lens		, (-11 1411)		-2.10	
4 5	-8.470 -9.951	0.46 0.50	1.58364	30.30	0.599							
6	31.833	0.10	1.50507	50.50	0.555			Ex	ample	81		
7*	15.267	2.87	1.49700	81.61	0.538	25		i i	pic	~ .		
8*	-7.030	0.10	1.01000	62.22	0.544	25						
9 10	11.408 -5.135	2.73 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583							
11	5.898	1.39	1./207/	5-1./1	0.505	_			Unit mm			
12(Stop)	∞	0.95				-						
13	-13.978	0.70	1.72047	34.71	0.583	a		S	urface dat	ta		
14 15	12.361 -9.042	2.62 0.05	1.61800	63.33	0.544	30	Surface no.	r	d	nd	νd	θgf
15 16*	13.037	3.38	1.49700	81.61	0.538	_	Surface no.	Г	a	па	va	ogi
17*	-8.022	1.85	1.15700	01.01	0.000		1	-4.999	2.50	1.53368	55.90	0.56
18*	60.912	0.50	1.58364	30.30	0.599		2*	-7.791	0.10			
19*	10.361	4.64					3*	26.421	2.58	1.84666	23.77	0.62
20 * 21	7.593 57.244	2.80 3.84	1.63490	23.88	0.630	35	4 5	-8.717 -16.546	0.45 0.50	1.58364	30.30	0.59
22	-9.323	0.50	1.53368	55.90	0.563		6	7.490	0.18	1.36304	30.30	0.55
23	402.242	1.68					7*	7.494	3.51	1.49700	81.61	0.53
24	-6.000	0.50	1.53368	55.90	0.563		8*	-6.731	0.10			
25* 26	39.607 ∞	0.90 0.30	1.51640	65.06	0.535		9 10	8.184 -9.417	2.60 0.70	1.61800 1.72047	63.33 34.71	0.54 0.58
27	∞	0.50	1.51040	03.00	0.555	40	11	5.248	1.23	1.72047	37.71	0.50
Image plane	, ∞						12(Stop)	∞	1.08			
						-	13	-8.120	0.70	1.72047	34.71	0.58
	Aspher	ical surfa	ce data			_	14 15	263.853 -8.897	2.25 0.05	1.61800	63.33	0.54
2n	ıd surface					•	16*	14.031	3.32	1.49700	81.61	0.53
_						- 45	17*	-8.260	0.05			
	= 0.000						18*	16.860	1.79	1.49700	81.61	0.53
	4 = 2.35623e-04 d surface						19* 20*	32.221 38.453	0.80 0.50	1.58364	30.30	0.59
310	a surrace					-	21*	8.351	3.63	1.50504	50.50	0.59
	= 0.000						22*	6.933	2.65	1.63490	23.88	0.63
	4 = -2.82645e - 0	4				50	23	26.183	4.93			
<u>7t1</u>	h surface					_	24 25*	-6.000	0.50	1.53368	55.90	0.56
b -	= 0.000						25* 26	12.318 ∞	2.01 0.30	1.51640	65.06	0.53
	- 0.000 4 = −2.81954e−0	5					27	∞	0.50	1.51040	05.00	0.55
	h surface					_	Image plane	∞				
1_	= 0.000					55 -		A1	rical surfa	an date		
A	= 0.000 4 = 5.97163e-04 5th surface					_	7 n	d surface	icai suffa	cc uata		
_						_	_					
	= 0.000 4 = -3.21151e-0	4				60	A	= 0.000 4 = 1.99427e-04 1 surface				
A	th surface					_	_					
A ²												
A4 <u>17</u> k = A4	7th surface = 0.000 4 = 4.81608e-05 3th surface					_	A	= 0.000 4 = -3.99767e-0 1 surface	4			
A ² 17 k = A ² 18	= 0.000 4 = 4.81608e-05					- 65	A4 7tl	1 = -3.99767e - 0	4			

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-continued	

		Unit mm			
20*	7.379	2.73	1.63490	23.88	0.630
21	40.501	5.73			
22	-6.000	0.50	1.53368	55.90	0.563
23*	11.000	2.01			
24	∞	0.30	1.51640	65.06	0.535
25	œ	0.50			
Image plane	∞				

Unit mm	
8th surface	
k = 0.000 A4 = 4.27793e-04 16th surface	
k = 0.000 A4 = -2.36647e - 04 17th surface	10
k = 0.000 A4 = -2.67152e-05 18th surface	
k = 0.000 A4 = 2.23589e-09 19th surface	
k = 0.000 A4 = -2.43051e-09 20th surface	20
k = 0.000 A4 = -1.76676e-04 21th surface	
k = 0.000 A4 = -4.16810e-04 22th surface	25
k = 0.000 A4 = -2.89542e-04 25th surface	30
k = 0.000 A4 = -8.76890e-04, A6 = 6.34071e-06	
Various data	
NA 0.32 Magnification -2.00 Focal length 4.27 Image height(mm) 3.87	35
fb(mm) (in air) 2.70 Lens total length(mm) (in air) 39.40	40

0.535

	Aspherical surface data
2nd	surface
A4	0.000 = -1.05936e-11 surface
A4	0.000 = -3.54087e-04 surface
A4	0.000 = -4.91474e-04 surface
A4	0.000 = 2.22934e-04 h surface
A4	0.000 = -5.25327e-04 h surface
A4	0.000 = 1.12098e-04 h surface
A4	0.000 = -1.70703e-05 h surface
A4	0.000 = -4.89824e-04 h surface
A4	0.000 = -3.06971e-04 h surface
	0.000 = -1.00102e-03, A6 = -4.72860e-06

Example 82

45	Various data								
	NA	0.32							
	Magnification	-2.00							
	Focal length	4.22							
	Image height(mm)	3.87							
50	fb(mm) (in air)	2.70							
	Lens total length(mm) (in air)	39.40							

		Unit mm			
	S	Surface dat	a		
Surface no.	r	d	nd	vd	θgf
1	-5.000	2.61	1.53368	55.90	0.563
2*	-6.052	0.10			
3*	29.971	2.45	1.84666	23.77	0.620
4	-8.900	0.10			
5	-12.880	0.50	1.58364	30.30	0.599
6	15.407	0.28			
7*	14.854	2.80	1.49700	81.61	0.538
8*	-7.113	0.10			
9	10.444	2.55	1.61800	63.33	0.544
10	-6.908	0.70	1.72047	34.71	0.583
11	5.463	1.42			
12(Stop)	∞	1.00			
13	-10.334	0.70	1.72047	34.71	0.583
14	16.417	2.68	1.61800	63.33	0.544
15	-7.780	0.05			
16*	12.572	3.57	1.49700	81.61	0.538
17*	-7.222	1.66			
18*	-222.930	0.50	1.58364	30.30	0.599
19*	9.006	3.98			

Example 83

			Unit mm			
60			Surface dat	а		
00	Surface no.	r	d	nd	vd	$\theta g f$
	1*	-8.255	2.60	1.53368	55.90	0.563
	2*	-14.196	1.24			
	3*	101.410	6.01	1.84666	23.77	0.620
65	4*	-20.773	6.49			
	5*	-16.458	1.50	1.58364	30.30	0.599

239	240
-continued	-continued

* *												
*		Unit mm							Unit mm			
	115.582	0.05				-	19th surfac	ce				
*	25.167	4.74	1.49700	81.61	0.538	5						
	-58.962	0.05					k = 0.000					
	108.206	3.90	1.49700	81.61	0.538			416e-06, $A6 = 2.2$	25200e-08	A8 = -1.04	000e-10	
*	-18.035 262.420	2.69 3.93	1.61800	63.33	0.544		20th surfac	ce				
	-14.956	0.59	1.72047	34.71	0.583		k = 0.000					
	30.541	6.11	1.72047	54.71	0.565	10		758e-06, A6 = 3.1	78128e-09	A8 = -8.78	028e-11	
Stop)	00	1.38					21th surfac			,		
• /	-26.136	0.63	1.72047	34.71	0.583							
	63.605	2.51	1.61800	63.33	0.544		k = 0.001					
	-37.610	0.05						0957e - 06, A6 = -	7.77920e-	-08, A8 = -7	.06650e-1	.2
	76.408	4.37	1.49700	81.61	0.538		22th surfac	ce				
	-22.777	0.05	4 40 500			15	k = 0.000					
	44.456	5.20	1.49700	81.61	0.538			913e-06, A6 = -3	06879e=0	18 Δ8 = _1 Δ	17637e-11	
	-44.738	3.37	1.50264	20.20	0.500		23th surfac		.000770	0,710 - 1	7,0576 11	
	-32.651	0.69	1.58364	30.30	0.599		2501501100					
	-325.190	0.05	1 (2400	22.00	0.630		k = -1487.	.500				
	27.615	4.73	1.63490	23.88	0.630	20		349e-06, $A6 = 1.8$	37699e-08	A8 = 1.461	37e-11	
	-102.253	19.80	1 52269	55.00	0.563	20	24th surfac	ce				
	-14.459	0.70	1.53368	55.90	0.563							
	-111.000	2.16	1 53260	55.00	0.562		k = -1.292					
	-17.656	1.10	1.53368	55.90	0.563			292e-06, $A6 = 9.6$	50 595e-1 0	A8 = 1.173	71e-10	
	110.376	1.20	1 51 640	65.00	0.525		25th surfac	ce				
	00	0.30	1.51640	65.06	0.535	25	1 27	. 5				
	00	0.50				23	k = -27.65		0.6427 0.0			
ge plane	00							0.89e - 0.6, $0.89e - 0.6$, $0.89e - 0.6$, $0.89e - 0.6$)6437e-08			
	Acnhe	rical surfa	ce data			_	26th surfac	<i></i>				
		iicai saiia	ce data			_	k = -0.383					
1st surface						– 30	A4 = -7.30 27th surfac	0149e-05, A6 = 4 se	.72395e-0	17, A8 = -3.5	6824e-09	1
k = -1.539							27111311111					
K = -1.539	05 46 - 3	90277a 0	7 49 - 21	6405a 10)		k = 0.000					
		.892776-0	I, Ab = -3.1	04936-10	,		14 - 2 501	150- 05 46 3	21047- 0	7 40 _ 00	9867e-10	ı
A4 = 1.48943e	, Au = -3.						A4 = 3.39	150e-05, $A6 = -3$.3184/e-U	17, A0 = -0.0	700,0 10	
						_	A4 = 3.39 28th surface		.31847e-U	7, Ao = -0.0	,500,6 10	
A4 = 1.48943e 2nd surface						-			.3184/e-0	77, A6 = -6.6		
A4 = 1.48943e 2nd surface $k = -2.553$			7.40.42	5200 10		- 35			.3184/e=0	77, Ao = -0.0		
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e			7, A8 = -4.3	5290e-10)	35	k = 0.000 $A4 = 5.685$	566e-05	.318476-0	77, Ao = -0.0		
A4 = 1.48943e 2nd surface $k = -2.553$			7, A8 = -4.3	5290e-10)	35	$\frac{28\text{th surfac}}{\text{k} = 0.000}$	566e-05	.318476-0	77, A6 = -6.6		
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface			7, A8 = -4.3	5290e-10)	35	28 th surface $k = 0.000$ $A4 = 5.685$ $29 th surface$	566e-05 ce	.318476-0	77, Ao = -0.0		
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000	e-05, A6 = -3.	.70903e-0)	35	28th surface k = 0.000 A4 = 5.685 29th surface k = -1058.	566e-05 be				
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface	e-05, A6 = -3.	.70903e-0)	_	28th surface k = 0.000 A4 = 5.685 29th surface k = -1058.	566e-05 ce				
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e	e-05, A6 = -3.	.70903e-0)	35 - 40	28th surface k = 0.000 A4 = 5.685 29th surface k = -1058.	566e-05 ce .583 6430e-04, A6 = -		-09, A8 = 6.6		
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e	e-05, A6 = -3.	.70903e-0)	_	28th surface k = 0.000 A4 = 5.685 29th surface k = -1058.	566e-05 ce .583 6430e-04, A6 = -	5.45019e-	-09, A8 = 6.6		
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface	e-05, A6 = -3.	.70903e-0	, A8 = -7.06	884e-12)	_	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20	566e-05 5ee .583 6430e-04, A6 = -	5.45019e-	-09, A8 = 6.6	0.33	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148	e-05, A6 = -3.	.70903e-0	, A8 = -7.06	884e-12)	_	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20	566e-05 566e-05 583 6430e-04, A6 = -	5.45019e-	-09, A8 = 6.6	0.33 -1.32	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e	e-05, A6 = -3.	.70903e-0	, A8 = -7.06	884e-12)	_	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma Foo	566e-05 ce .583 6430e-04, A6 = -	5.45019e-	-09, A8 = 6.6	0.33 -1.32 9.91	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e	e-05, A6 = -3.	.70903e-0	, A8 = -7.06	884e-12)	_ 40 _	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma Foot	566e-05 see .583 6430e-04, A6 = - gnification cal length age height(mm)	5.45019e-	-09, A8 = 6.6	0.33 -1.32 9.91 10.82	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1	.70903e-0	, A8 = -7.06 , A8 = -1.79	884e-12 459e-11)	_	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	566e-05 see 583 6430e-04, A6 = - gnification cal length age height(mm) mm) (in air)	5.45019e- Various dat	-09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1	.70903e-0	, A8 = -7.06 , A8 = -1.79	884e-12 459e-11)	_ 40 _	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	566e-05 see .583 6430e-04, A6 = - gnification cal length age height(mm)	5.45019e- Various dat	-09, A8 = 6.6	0.33 -1.32 9.91 10.82	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1	.70903e-0	, A8 = -7.06 , A8 = -1.79	884e-12 459e-11)	_ 40 _	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	566e-05 see 583 6430e-04, A6 = - gnification cal length age height(mm) mm) (in air)	5.45019e- Various dat	-09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	see 2566e-05 see 25.583 see 25.58	.5.45019e- Various dat n) (in air)	.09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _ 45	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	see 2566e-05 see 25.583 see 25.58	5.45019e- Various dat	.09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	see 2566e-05 see 25.583 see 25.58	.5.45019e- Various dat n) (in air)	.09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _ 45	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	see 2566e-05 see 25.583 see 25.58	.5.45019e- Various dat n) (in air)	.09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08 :7309e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _ 45	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	see 2566e-05 see 25.583 see 25.58	.5.45019e- Various dat n) (in air)	.09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08 :7309e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _ 45	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	see 2566e-05 see 25.583 see 25.58	5.45019e- Various dat n) (in air) xample s	.09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08 :7309e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _ 45	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	see 2566e-05 see 25.583 see 25.58	.5.45019e- Various dat n) (in air)	.09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3	.70903e-0 99183e-09 0988e-08 :7309e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063	884e-12 459e-11 88e-10		_ 40 _ 45	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	gnification cal length age height(mm) ms total length(mm)	5.45019e- Various dat n) (in air) xample s	-09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 e-06, A6 = -0 e-06, A6 = 6.9	.70903e-0 99183e-09 0988e-08 .7309e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6	884e-12 459e-11 88e-10		_ 40 _ 45 _ 50	28th surfac k = 0.000 A4 = 5.68i 29th surfac k = -1058. A4 = -1.20 NA Ma Foc Im. fb() Len	see 2566e-05 see 2583 6430e-04, A6 = -	5.45019e- Various dat n) (in air) xample s Unit mm	09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90 88.59	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 e-06, A6 = -0 e-06, A6 = 6.9	.70903e-0 99183e-09 0988e-08 .7309e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6	884e-12 459e-11 88e-10		_ 40 _ 45 _ 50	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma From Image of the control of	gnification cal length age height(mm) ms total length(mm)	.5.45019e- Various dat n) (in air) xample \(\)	-09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -2.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 e-06, A6 = -0 e-06, A6 = 6.9	.70903e-0 99183e-09 0988e-08 .7309e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6	884e-12 459e-11 88e-10		_ 40 _ 45 _ 50	28th surfac k = 0.000 A4 = 5.68i 29th surfac k = -1058. A4 = -1.20 NA Ma Foc Im. fb() Len	see 2566e-05 see 2583 6430e-04, A6 = -	5.45019e- Various dat n) (in air) xample s Unit mm	09, A8 = 6.6	0.33 -1.32 9.91 10.82 1.90 88.59	
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 e-06, A6 = -0 e-06, A6 = 6.9	.70903e-0 99183e-09 0988e-08 .7309e-08 1.66723e- 23196e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6	884e-12 459e-11 88e-10		_ 40 _ 45 _ 50	28th surfac k = 0.000 A4 = 5.68t 29th surfac k = -1058. A4 = -1.20 NA Ma Foo Im fb() Lei	r	5.45019e- Various dat n) (in air) xample S Unit mm Surface dat d	a nd	0.33 -1.32 9.91 10.82 1.90 88.59	θg 0.53
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000 A4 = -6.36933	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 e-06, A6 = -0 e-06, A6 = 6.9	.70903e-0 99183e-09 0988e-08 .7309e-08 1.66723e- 23196e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6	884e-12 459e-11 88e-10		_ 40 _ 45 _ 50 _ 55	28th surface k = 0.000 A4 = 5.68: 29th surface k = -1058. A4 = -1.20 NA Ma Foo Im: fb(: Let) Surface no.	see	5.45019e- Various dat n) (in air) Xample 3 Unit mm Surface dat d 3.32	a nd 1.49700	0.33 -1.32 9.91 10.82 1.90 88.59 vd	θg 0.53
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 e-06, A6 = -0 e-06, A6 = 6.9	.70903e-0 99183e-09 0988e-08 .7309e-08 1.66723e- 23196e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6	884e-12 459e-11 88e-10		_ 40 _ 45 _ 50	28th surface k = 0.000 A4 = 5.68t 29th surface k = -1058. A4 = -1.20 NA Ma Foo Im fb() Let Surface no.	see 2566e-05 see 2583	5.45019e- Various dat n) (in air) Unit mm Surface dat d 3.32 0.70	a nd 1.49700	0.33 -1.32 9.91 10.82 1.90 88.59 vd	θд
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -2.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000 A4 = -6.36933 10th surface	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 e-06, A6 = -0 e-06, A6 = 6.9	.70903e-0 99183e-09 0988e-08 .7309e-08 1.66723e- 23196e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6	884e-12 459e-11 88e-10		_ 40 _ 45 _ 50 _ 55	28th surface k = 0.000 A4 = 5.68t 29th surface k = -1058. A4 = -1.20 NA Ma Foo Ima fb() Let Surface no. 1 2 3 4* 5*	ce 5.66e-05 ce 5.66e-05 ce 5.683 ce 6.430e-04, A6 = -1.583 ce 6.430e-04, A6 = -1.58 ce 6.430e-04, A6 = -1.58 ce 6.58 c	5.45019e- Various dat (in air) Unit mm Surface dat d 3.32 0.70 0.05 1.03 0.35	a 1.49700 1.72047 1.53368	0.33 -1.32 9.91 10.82 1.90 88.59 vd 81.54 34.71 55.90	θg 0.5:5 0.58
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -2.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000 A4 = -6.36933 10th surface k = -3.004	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 8e-06, A6 = -6.9 e-06, A6 = 2.4	.70903e-0 9183e-09 0988e-08 :7309e-08 1.66723e- 93196e-08 :3563e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6 , A8 = 2.245	884e-12 459e-11 88e-10 6467e-10		_ 40 _ 45 _ 50 _ 55	28th surface k = 0.000 A4 = 5.68t 29th surface k = -1058. A4 = -1.20 NA Ma Foo Image fb(i Let Surface no. 1 2 3 4* 5* 6*	see 5.66e-05 see 5.683 6430e-04, A6 = -1.78 feet feet feet feet feet feet feet fee	5.45019e- Various dat (in air) Unit mm Surface dat d 3.32 0.70 0.05 1.03 0.35 1.07	a nd 1.49700 1.72047	0.33 -1.32 9.91 10.82 1.90 88.59 vd	θg 0.5:5 0.58
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -2.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000 A4 = -6.36933 10th surface k = -3.004 A4 = 8.21883e	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 8e-06, A6 = -6.9 e-06, A6 = 2.4	.70903e-0 9183e-09 0988e-08 :7309e-08 1.66723e- 93196e-08 :3563e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6 , A8 = 2.245	884e-12 459e-11 88e-10 6467e-10		_ 40 _ 45 _ 50 _ 55	28th surface k = 0.000 A4 = 5.68: 29th surface k = -1058. A4 = -1.20 NA Ma Foo Im: fb0: Let Surface no. 1 2 3 4* 5* 6* 7*	ce 5.66e-05 ce 5.66e-05 ce 6.583 6430e-04, A6 = - cal length age height(mm) (in air) as total length(mn as t	5.45019e- Various dat (in air) Unit mm Surface dat d 3.32 0.70 0.05 1.03 0.35 1.07 1.34	a 1.49700 1.72047 1.53368	0.33 -1.32 9.91 10.82 1.90 88.59 vd 81.54 34.71 55.90	θg 0.5:5 0.58
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -2.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000 A4 = -6.36933 10th surface k = -3.004	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 8e-06, A6 = -6.9 e-06, A6 = 2.4	.70903e-0 9183e-09 0988e-08 :7309e-08 1.66723e- 93196e-08 :3563e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6 , A8 = 2.245	884e-12 459e-11 88e-10 6467e-10		_ 40 _ 45 _ 50 _ 55	28th surface k = 0.000 A4 = 5.68t 29th surface k = -1058 A4 = -1.20 NA Ma Foo Im: fb(: Lei Surface no. 1 2 3 4* 5* 6* 7* 8(Stop)	r 5.522 -4.753 -6.534 -11.725 -2.515 2.408 1.032 6.666e-05 Dee See See See See See See Se	5.45019e- Various dat (in air) Unit mm Surface dat d 3.32 0.70 0.05 1.03 0.35 1.07 1.34 -0.63	nd 1.49700 1.72047 1.53368 1.58364	vd 81.54 34.71 55.90 30.30	θg 0.55 0.58 0.56 0.59
A4 = 1.48943e 2nd surface k = -2.553 A4 = 8.26430e 3rd surface k = 0.000 A4 = 5.57538e 4th surface k = -0.148 A4 = 1.09741e 5th surface k = -0.223 A4 = 2.76548e 6th surface k = -29.473 A4 = -5.12018 7th surface k = -2.649 A4 = 2.86256e 8th surface k = 0.000 A4 = 4.46646e 9th surface k = 0.000 A4 = -6.36933 10th surface k = -3.004 A4 = 8.21883e	e-05, A6 = -3.0 e-06, A6 = 3.0 e-05, A6 = 4.1 e-06, A6 = 9.3 8e-06, A6 = -6.9 e-06, A6 = 2.4	.70903e-0 9183e-09 0988e-08 :7309e-08 1.66723e- 93196e-08 :3563e-08	, A8 = -7.06 , A8 = -1.79 , A8 = 1.063 08, A8 = 2.6 , A8 = 2.245	884e-12 459e-11 88e-10 6467e-10		_ 40 _ 45 _ 50 _ 55	28th surface k = 0.000 A4 = 5.68: 29th surface k = -1058. A4 = -1.20 NA Ma Foo Im: fb0: Let Surface no. 1 2 3 4* 5* 6* 7*	ce 5.66e-05 ce 5.66e-05 ce 6.583 6430e-04, A6 = - cal length age height(mm) (in air) as total length(mn as t	5.45019e- Various dat (in air) Unit mm Surface dat d 3.32 0.70 0.05 1.03 0.35 1.07 1.34	a 1.49700 1.72047 1.53368	0.33 -1.32 9.91 10.82 1.90 88.59 vd 81.54 34.71 55.90	θg 0.5:5 0.58

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	-	continue	ed				-continued						
		Unit mm							Unit mm				
•	3.627 -10.317	2.78 0.64	1.53368	55.90	0.563	5	>20th surface						
: :	-20.884 36.783 70.302	0.43 0.98 0.36	1.58364	30.30	0.599		k = -2.861 A4 = -1.60534e-03, A6 = 1.89038e-04, A8 = -1.72789e-05						
:	-113.857 -2.520	2.13 0.73	1.53368	55.90	0.563	_			arious da				
	5.467 1.773	1.41 3.00	1.53368	55.90	0.563	10 _	NI A	0.42	0.42				
ige plane	& & &	0.30 2.68	1.51640	65.06	0.535	_	NA Magnii Focal l Image	0.42 -2.54 5.60 2.82					
	Asph	erical surfa	ce data			15) (in air) otal length(mm	ı) (in air)		5.88 24.78		
4th surface						_ -	Lens to	rai lengin(mm	(III ali)		24.76		
k = -2.346 A4 = -5.47816e-04, A6 = -1.85200e-05, A8 = -1.11713e-06 5th surface								Ех	kample	85			
k = -4.656 $A4 = -1.453$ 6th surface	735e-03, A6 = 1	1.26259e-0)4, A8 = -9.0	7838e-01	7	_							
k = -0.427									Unit mm				
	657e-02, A6 = 1	1.04387e-0	3, A8 = -1.4	3077e-04	1	25 _		S	urface da	ta			
k = -1.871						_	Surface no.	r	d	nd	νd	θgf	
A4 = 1.0827 9th surface	73e-02, A6 = -	1.21053e=0	94, A8 = -1.0	9274e-04	1	- 30	1* 2* 3*	-5.514 -11.922 5.778	1.29 0.05 1.67	1.53368 1.63490	55.90 23.88	0.563	
k = -1.286						- 30	4* 5*	-29.284 4.017	0.05 1.87	1.49700	81.61	0.53	
A4 = -9.36? 10th surface	741e-04, A6 = 5	5.67573e=0	94, A8 = 9.10	428e-05		_	6* 7	-15.570 34.714	0.05 1.69	1.61800	63.33	0.544	
k = -2.245 $A4 = -4.605$	559e-03, A6 = 8	3.95601e-0)4, A8 = 6.69	421e-06		35	8 9 10 (Stop)	-3.637 6.126 ∞	0.50 0.50 0.57	1.72047	34.71	0.583	
11th surface	•					_	11 12	-4.026 6.286	0.50 2.41	1.72047 1.61800	34.71 63.33	0.583	
k = -934.66 A4 = -1.823 12th surface	784e-02, $A6 = 2$	2.13051e-0	3, A8 = -1.1	4784e-04	1		13 14* 15*	-4.605 4.993 -10.575	0.05 3.09 4.34	1.49700	81.61	0.538	
k = -5.112						_ 40	16* 17*	-3.072 12.916	0.50 3.27	1.58364	30.30	0.599	
A4 = -4.076 $13th surface$	587e-04, A6 = -	-4.69186e-	-04, A8 = 1.5	1357e-04	1	_	18* 19* 20*	34.808 -5.789 5.466	2.40 0.05 3.30	1.63490 1.53368	23.88	0.630	
k = -0.526	202 04 46 7)5 . 0 667	1964 06		45	21* 22	2.769 ∞	2.00 0.30	1.51640	65.06	0.535	
A4 = -3.382 $14th surface$	283e-04, A6 = 3	3.66199e=0	05, A8 = 6.67	864e-06		_	23 Image	& &	1.21				
	11e-04, A6 = -	1.97950e=0)5, A8 = -3.5	2754e-01	7	-	plane	Asphei	rical surfa	ce data			
15th surface						_ 50 -	1st surface						
k = -0.461 A4 = -4.063 16th surface	730e-05, A6 = 0	5.44269e-0	06, A8 = -9.1	1321e-01	7	_	k = -12.202 A4 = 1.845396 2nd surface	e-03, A 6 = 3.7	2790e-04	I, A8 = -1.11	934e-05		
k = -633.16 $A4 = -8.541$ 17th surface	163e-03, A6 = 1	7.70310e-0)4, A8 = -2.2	:4802e-05	5	55	k = -1.452 $A4 = 1.422846$ 3rd surface	e-04, A6 = -2.	93804e-0	05, A8 = 1.26	i134e-05		
k = -9931.442 A4 = -9.69825e-03, A6 = 9.38022e-04, A8 = -3.70711e-05 18th surface													
k = -3.263 A4 = -3.497 19th surface	796e-03, A6 = 2	2.98375e-0)4, A8 = -1.7	/2732e-05	5	_	k = -234.585 A4 = 3.568646 5th surface	e-04, A6 = 4.5	1097e-05	5, A8 = 6.126	25e-07		
k = 0.012 $A4 = -2.757$	744e-03, A6 = 1	1.27065e-0)4, A8 = -1.1	4029e-05	5	65	k = -2.940 $A4 = -8.89164$	4e-04, A6 = -	7.32674e-	-05, A8 = -4	.90767e-0)6	

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	·											
		Unit mm							Unit mm	ı		
6th surface						_ 5	16*	-3.264	0.50	1.58364	30.30	0.59
	_					- 5	17*	16.176	2.44			
k = 4.395	05.15	00000 -			-		18*	30.183	2.05	1.63490	23.88	0.63
A4 = 2.86421e 14th surface	-05, A6 = -8 .	09298e=0	$y_3, A8 = -2.5$	0197/e-06)		19* 20*	-5.566 4.781	0.05	1.53368	55.90	0.56
1+ui suriace						_	20*	4.781 2.375	3.10 2.00	1.33308	J J.9 U	0.50.
k = -0.616							22	2.373 00	0.30	1.51640	65.06	0.53
A4 = -4.85884	4e-04, $A6 = -3$	3.21813e-	-06, A8 = -2	.60788e-0	07	10	23	œ	0.80			
15th surface	· .					_	Image	∞				
k = 0.121						_	plane					
A4 = 3.77898e 16th surface	e-05, A6 = -2.	13024e-0)5, A8 = 5.58	090e-07		_		Asphe	rical surfa	ace data		
k = -0.444						15	1st surface					
A4 = 2.49937e 17th surface	e-03, $A6 = -2$.	65748e-0	05, A8 = -3.5	4361e-06	5		k = -3.628	00.03.44 3	217/0~ /	N AR 500	nssa ne	
k = 0.000						_	2nd surface	0e-03, A6 = -2	.31/486-0	04, A8 = 3.92 	.9336-US	
A4 = 0.000 A4 = 1.53490e	e-03, $A6 = 1.1$	5188e-04	A8 = -1.26	803e-05		20						
18th surface	. 55,210 - 1.1.	. 1000 07	., 1.20	2000 00		20	k = -4.147					
						_		8e-04, A6 = -1	.64515e=(04, A8 = 1.62	2/66e-05	
k = -55.238					_		3rd surface					
A4 = -4.63820	,	5.23030e-	-05, A8 = 4.9	7870e-07	7,		k = -0.230					
A10 = 3.80003	se-08							4e-04, A6 = 5.4	13421e=04	5. A8 = 4 730	02e=06	
19th surface						- 25	4th surface	v-, nv = 3.4	.J-216-00	z, z xo − +.730	020-00	
k = -0.135							surface					
A4 = 7.41400e	e-05, A6 = 7.3	6376e-06	5, A8 = -1.55	794e-06,			k = -128.688	3				
A10 = 3.62379				ŕ			A4 = 2.32019	9e-05, A6 = 4.0)4905e-05	5, A8 = 8.007	33e-06	
20th surface						_	5th surface					
lr _ 1 522						30						
k = -1.532 A4 = -8.00176	Se=04 A6 = 6	139900)5 A8 = 2 02	773e-06		50	k = -2.606	12 04 15 =	ommes :			
A4 = -8.00170 A10 = -7.5057		10090 C- U	,110 - 2.02	.,,50-00,				13e-04, A6 = 5	.07700e=0	10, A8 = -4.3	5/050e=06)
							6th surface					
21th surface												
21th surface						_						
$\frac{21 \text{th surface}}{k = -0.303}$						-	k = 6.614	28e-04 A6 = -	3.9691 6e-	-05. A8 = -5	.59983e=0)7
21th surface k = -0.303 A4 = -7.75557		59034e-0)5, A8 = -1.6	60 847e –06	5,	35	k = 6.614	28e-04, A6 = -	3.96916e-	-05, A8 = -5	.59983e-0)7
21th surface k = -0.303 A4 = -7.75557		59034e-0	05, A 8 = -1.6	60847e-06	5,	35	k = 6.614 $A4 = -1.779$	28e-04, A6 = -	3.96916e-	-05, A8 = -5	.59983e-0)7
21th surface	06e-07	59034e-0 7arious dat		60847e-06	5,	35	k = 6.614 A4 = -1.779 14th surface k = -0.665	<u> </u>				
21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050	06e-07				5,	35	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371	28e-04, A6 = - 73e-04, A6 = 3				
21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050	06e-07 V			0.40	5,	35	k = 6.614 A4 = -1.779 14th surface k = -0.665	<u> </u>				
21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050 NA Magnif	06e-07 V			0.40 -2.58	5,	35 - - 40	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371 15th surface	<u> </u>				
21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050 NA Magnif Focal le	06e-07 V fication ength			0.40 -2.58 6.09	5,	-	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371 15th surface k = -0.288	73e-04, A6 = 3	.43918e-(06, A8 = -3.6	58651e-07	
21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050 NA Magnif Focal le Image l	06e-07 Vification ength height (mm)			0.40 -2.58 6.09 2.86	5,	-	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371 15th surface k = -0.288 A4 = 6.9543	<u> </u>	.43918e-(06, A8 = -3.6	58651e-07	
21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050 NA Magnif Focal le Image I fb (mm	06e-07 V fication ength	⁷ arious dat		0.40 -2.58 6.09	5,	-	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371 15th surface k = -0.288	73e-04, A6 = 3	.43918e-(06, A8 = -3.6	58651e-07	
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21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050 NA Magnif Focal le Image I fb (mm Lens to Surface no. 1* 2* 3* 4* 5* 6* 7 8 9 10 (Stop)	Ex Gleation ength height (mm) i) (in air) stal length (mn Ex S r -2.994 -8.073 6.018 -20.490 3.224 -12.832 -29.415 -3.584 8.995	Various date of the control of the c	1.53368 1.63490 1.49700 1.72047	vd 55.90 23.88 81.61 63.33 34.71	θgf 0.563 0.630 0.538 0.544 0.583	40 45 50 55	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371 15th surface k = -0.288 A4 = 6.9543: 16th surface k = -0.710 A4 = 4.6716: 17th surface k = -0.162 A4 = 4.3202: 18th surface k = -0.001 A4 = -2.626 A10 = 1.734: 19th surface k = 0.002 A4 = -3.817: A10 = 8.836: 20th surface k = -2.233 A4 = -1.787: A10 = -6.32: 21th surface k = -0.253	73e-04, A6 = 3 8e-05, A6 = -1 6e-03, A6 = -3 7e-03, A6 = -4 57e-04, A6 = -3 9e-07 07e-04, A6 = -3 30e-08	.43918e-(.77347e-(.63236e-(.81582e-(2.72183e- 1.42470e- .38140e-(06, A8 = -3.6 05, A8 = 4.94 04, A8 = 1.79 05, A8 = 5.13 -04, A8 = 8.7 -05, A8 = -2	58651e-07 1606e-07 1484e-05 1546e-06 171964e-06	, , , , , ,
21th surface k = -0.303 A4 = -7.75557 A10 = -3.3050 NA Magnif Focal k Image I fb (mm Lens to Surface no. 1* 2* 3* 4* 5* 6* 7 8 9 10 (Stop) 11 12 13	Ex S r -2.994 -8.073 6.018 -20.490 3.224 -12.832 -29.415 -3.584 8.995 -4.307 7.428 -4.986	Various data (mair) (in air) (in air) (ample 3 (ample 4 (ample 4 (ample 5 (1.53368 1.63490 1.49700 1.61800 1.72047 1.72047	vd 55.90 23.88 81.61 63.33 34.71 34.71 63.33	θgf 0.563 0.630 0.538 0.544 0.583 0.544	40 45 50 55 60	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371 15th surface k = -0.288 A4 = 6.9543: 16th surface k = -0.710 A4 = 4.6716: 17th surface k = -0.162 A4 = 4.3202' 18th surface k = -0.001 A4 = -2.626 A10 = 1.734: 19th surface k = 0.002 A4 = -3.817: A10 = 8.836: 20th surface k = -2.233 A4 = -1.787: A10 = -6.32' 21th surface k = -0.253 A4 = -1.474	73e-04, A6 = 3 8e-05, A6 = -1 6e-03, A6 = -3 7e-03, A6 = -4 57e-04, A6 = -3 9e-07 07e-04, A6 = -3 30e-08 49e-03, A6 = 1 913e-07	.43918e-(.77347e-(.63236e-(.81582e-(2.72183e- 1.42470e- .38140e-(06, A8 = -3.6 05, A8 = 4.94 04, A8 = 1.79 05, A8 = 5.13 -04, A8 = 8.7 -05, A8 = -2	58651e-07 1606e-07 1484e-05 1546e-06 171964e-06	, , , , , ,
21th surface x = -0.303 A4 = -7.75557 A10 = -3.3050 NA Magnif Focal le Image I fb (mm Lens to Surface no. 1* 2* 3* 4* 5* 6* 7 8 9 10 (Stop) 11 12	Ex S r -2.994 -8.073 6.018 -20.490 3.224 -12.832 -29.415 -3.584 8.995 -4.307 7.428	Various date of the control of the c	nd 1.53368 1.63490 1.49700 1.61800 1.72047	vd 55.90 23.88 81.61 63.33 34.71 34.71	θgf 0.563 0.630 0.538 0.544 0.583	40 45 50 55	k = 6.614 A4 = -1.779 14th surface k = -0.665 A4 = -6.371 15th surface k = -0.288 A4 = 6.9543: 16th surface k = -0.710 A4 = 4.6716: 17th surface k = -0.162 A4 = 4.3202: 18th surface k = -0.001 A4 = -2.626 A10 = 1.734: 19th surface k = 0.002 A4 = -3.817: A10 = 8.836: 20th surface k = -2.233 A4 = -1.787: A10 = -6.32: 21th surface k = -0.253	73e-04, A6 = 3 8e-05, A6 = -1 6e-03, A6 = -3 7e-03, A6 = -4 57e-04, A6 = -3 9e-07 07e-04, A6 = -3 30e-08 49e-03, A6 = 1 913e-07	.43918e-(.77347e-(.63236e-(.81582e-(2.72183e- 1.42470e- .38140e-(06, A8 = -3.6 05, A8 = 4.94 04, A8 = 1.79 05, A8 = 5.13 -04, A8 = 8.7 -05, A8 = -2	58651e-07 1606e-07 1484e-05 1546e-06 171964e-06	, , , , , ,

		245			03 9,.				246						
	-(continue	ed					-(continue	ed					
		Unit mm							Unit mm						
	V	/arious da	ta			_ 5	15th surface								
Focal	fication length height (mm)			0.40 -1.99 5.65 2.30		•	k = -0.269 A4 = 1.80079e 16th surface	:-04, A6 = -4.	.28347e-(05, A 8 = 9.77	123e-07				
fb (mn	n) (in air) otal length (mn	n) (in air)		3.00 29.24		10	k = -0.713 A4 = 4.316756 17th surface	:-03, A6 = -2.	.71566e-(04, A8 = 3.38	626e-06				
	Ex	kample	87				k = -0.493 A4 = 3.60750e 18th surface	-03, A6 = -1	.95719e-()4, A8 = 2.22	810e-06				
						15 -	k = -78.870 A4 = 1.08920e	-03, A6 = -2	.97701e-(04. A8 = 1.06	145e-05.				
		Unit mm				_	A10 = -4.4740 19th surface			.,,,,,,					
	S	urface dat	ta			_									
Surface no.	r	d	nd	νd	θgf	20	k = -0.052 $A4 = -7.53657$ $A10 = 1.95988$		8.77181e-	-07, A8 = -1	.92215e-()6,			
1* 2*	-3.798 -6.396	1.90 0.05	1.53368	55.90	0.563		20th surface								
3* 4*	7.086 -9.324	2.06 0.18	1.63490	23.88	0.630		k = -2.024 A4 = -4.21997e-03, A6 = 1.26487e-04, A8 = 1.39491e-0.								
5* 6*	3.430	2.38 0.06	1.49700	81.61	0.538	25	A10 = -4.1998		.201070	71,710 11.57	1,710 00,				
7	-13.065 -11.385	1.90	1.61800	63.33	0.544		21th surface								
8	-3.594	0.50	1.72047	34.71	0.583		k = -0.889								
9 10 (Stop)	16.094 ∞	0.33					A4 = -2.88436 A10 = 2.08658		.04215e=0	03, A8 = -2.4	-2.40665e-04,				
11	-16.057	0.50	1.72047	34.71	0.583	30 -	7110 - 2.00050								
12 13	5.835 -8.690	2.86 0.05	1.61800	63.33	0.544			7	/arious da	ta					
14*	6.232	4.02	1.49700	81.61	0.538	_	NA				0.74				
15*	-9.315	3.51	1.50264	20.20	0.500		Magnif				-4.18				
16* 17*	-4.074 -8.282	3.92 2.17	1.58364	30.30	0.599	35	Focal le	ength height (mm)			2.80 2.23				
18*	-13.370	2.21	1.63490	23.88	0.630	33	fb (mm) (in air)			5.53				
19* 20*	-7.760 3.535	1.21 3.61	1.53368	55.90	0.563		Lens to	tal length (mr	n) (in air)		39.27				
21*	1.476	4.00	1.55500	33.70	0.505	-									
22	∞	0.30	1.51640	65.06	0.535										
23 Image	∞ ∞	1.33				40		Ez	kample	88					
plane	•														
	Asphei	rical surfa	ce data						T.T., 14						
1st surface						- - 45			Unit mm Surface da						
	6e-04, A6 = -9	9.63910e-	-03, A8 = 4.9	9 2454e –03	3	_	Surface no.	r	d	nd	vd	θg			
2nd surface							1*	-2.732	1.36	1.53368	55.90	0.56			
k = 5.942	00.02.46.7	12002 - 1	1/ AP 1/	2696- 0	1	50	2*	-4.589	0.05	1 62400	22.00	0.00			
A4 = -1.1869 3rd surface	9e-02, A6 = 7.	.12983e-()4, A8 = −1.5)3086e-04	+	50	3* 4*	7.247 -8.455	1.87 0.05	1.63490	23.88	0.63			
						-	5*	3.138	2.15	1.49700	81.61	0.53			
$k = -0.447$ $\Delta 4 = -1.0736$	8e-04, A6 = 6.	28002= 0	05 A8 = -74	1610201	7		6 * 7	-12.154 -15.110	0.04 1.79	1.61800	63.33	0.54			
4th surface	ov-o-, Ato = 0.	.20/020-0	.s, no = -1.5	101020-0	,		8	-3.447	0.50	1.72047	34.71	0.54			
1 10:						55	9	25.308	0.17						
k = -16.463 A4 = 4.48373	e-04, A6 = 1.1	8444e=04	1. A8 = -4 32	2048e-06			10 (Stop) 11	∞ 110.943	-0.01 0.50	1.72047	34.71	0.58			
5th surface	- 01,710 - 1.1	5 1 1 rc-04	.,. 10 1.52	20 100-00			12	4.107	2.60	1.61800	63.33	0.54			
1- 2.742						_	13	-9.964 5.280	0.05	1.40700	01.61	0.55			
k = -2.743 A4 = -6.9709	8e-04, A6 = -3	3.36286e-	-05. A8 = 2.9	94162e=01	7		14* 15*	5.280 -11.739	2.65 3.54	1.49700	81.61	0.53			
6th surface					·	60	16*	-3.025	2.06	1.58364	30.30	0.59			
1 0.641						_	17*	-7.825	1.50	1 62 400	22.00	0.65			
k = 9.641 A4 = -8.5670	5e-04, A6 = -	1.66634e-	-05, $A8 = 4$	35943e=0 <i>6</i>	5		18* 19*	-15.729 -5.597	2.16 0.34	1.63490	23.88	0.63			
14th surface						_	20*	3.756	3.64	1.53368	55.90	0.56			
1- 0.005						- 65	21*	1.383	2.00	1.51.640	65.00	0.55			
k = -0.885 A4 = -8.8209	4e-04, A6 = -	1 120424	-05 A8 - 61	24152e_01	7	0.5	22 23	& &	0.30 1.54	1.51640	65.06	0.53			
0.0207	, , , , , , , , , , , , , , , , ,	U-TZ-U-	0.2	- 11020-0	•			••	1.07						

-continued

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Image ∞ plane	5	Unit mm							
-			S	urface dat	a				
Aspherical surface data	_	Surface no.	r	d	nd	νd	θgf		
1st surface		1*	-5.138	2.14	1.53368	55.90	0.56		
k = -2.227	10	2*	-6.198	0.05	1.55500	33.90	0.50		
A4 = 1.03707e - 03, $A6 = -3.66686e - 03$, $A8 = 2.87380e - 032nd surface$		3*	8.105	2.22	1.63490	23.88	0.63		
2nd Market		4* 5*	-11.185 3.574	0.05 3.37	1.49700	81.61	0.53		
k = 3.573		6*	-13.843	0.05	1.42700	01.01	0.55		
A4 = -1.72203e-02, A6 = 2.19859e-03, A8 = -3.34713e-04		7	-14.787	2.55	1.61800	63.33	0.54		
3rd surface	15	8	-4.610	0.53	1.72047	34.71	0.58		
k = 0.001		9 10 (Stop)	125.202 ∞	0.12 0.37					
A4 = 6.91776e - 04, $A6 = 2.83494e - 05$, $A8 = 8.43494e - 09$		10 (Stop) 11	-29.837	0.53	1.72047	34.71	0.58		
4th surface		12	7.231	2.99	1.61800	63.33	0.54		
k = -16.058		13	-33.219	0.05					
A4 = 5.58712e-04, A6 = 1.20511e-04, A8 = -1.10589e-06	20	14*	7.572	2.49	1.49700	81.61	0.53		
5th surface		15* 16*	-27.697 33.001	0.10 3.56	1.49700	81.61	0.53		
		17*	-10.371	2.80	1.49700	61.01	0.55		
k = -3.338		18*	-4.952	1.36	1.58364	30.30	0.59		
A4 = -9.15433e-04, $A6 = 1.68698e-05$, $A8 = -5.04647e-066th surface$		19*	-14.665	3.75					
our surface	25	20*	-17.212	2.97	1.63490	23.88	0.63		
k = 10.493		21* 22*	-7.864 3.950	0.96 4.37	1.53368	55.90	0.56		
A4 = -4.85932e - 04, $A6 = -8.48143e - 07$, $A8 = 2.87740e - 06$		23*	1.555	3.21	1.55500	33.90	0.50		
14th surface		24	00	0.30	1.51640	65.06	0.53		
1 0000		25	∞	11.94					
k = -0.972 A4 = -9.54935e-04, $A6 = -1.60895e-05$, $A8 = 9.62636e-0715th surface$	30	Image plane	∞						
			Asphei	ical surfa	ce data				
k = 0.853 A4 = 7.88421e-05, A6 = -7.27968e-05, A8 = 1.26076e-06	-	1st surface							
A4 = 7.884216-03, $A6 = -7.279086-03$, $A8 = 1.200706-0016th surface$		1st surface							
Total starace	35	k = -88.989							
k = -0.842 A4 = 4.87822e-03, A6 = -3.71445e-04, A8 = -1.52508e-05		A4 = -5.99353 2nd surface	7e-03, A6 = 6.	73377e=0	3, A8 = -4.6	51378e-03			
17th surface		k = 5.622							
k = -1.191		A4 = -9.89655	5e-03, $A6 = 8$.	20507e-0	4, A8 = -1.5	0643e-04	ŀ		
A4 = 3.67852e - 03, $A6 = -5.93789e - 05$, $A8 = -5.04387e - 06$	40	3rd surface							
18th surface		k = -1.540							
		K = -1.540 A4 = -4.59240	5e-04 A6 = 1	09257e=0	14 A8 = -3 1	8105e-06	i		
k = -144.172		4th surface	0 01,710 - 1.	0,25,0	71,710 - 5.1	.01050 00	,		
A4 = 1.13639e - 03, $A6 = -4.17245e - 04$, $A8 = 1.97474e - 05$,									
A10 = -9.49865e - 07	45	k = -25.930	04.46.44	1072 61		224- 05			
19th surface		A4 = 6.832446 5th surface	:-04, Ab = 1.1	1972e-04	+, A8 = -2.05	324e-06			
k = 0.008		Jan Bantace							
A4 = -8.04993e - 04, $A6 = 1.17608e - 05$, $A8 = -2.70155e - 06$,		k = -3.141							
A10 = -3.55017e - 08		A4 = -3.44558	Be-04, A6 = -:	5.70704e-	-06, A8 = -5	.53375e-0	8(
20th surface	50	6th surface							
k = -2 462		k = 7 221							
k = -2.462 A4 = -6.02434e - 03, $A6 = -6.10236e - 07$, $A8 = 4.06972e - 05$,		k = 7.221 A4 = -9.36274	1e-04 A6	L 66810a	-05 A8 - 2 C)4119e=06	i		
A4 = -0.02434e - 03, $A6 = -0.10230e - 07$, $A8 = 4.00972e - 03$, $A10 = -1.31050e - 06$		14th surface	.v-, 110		05, 110 - 2.0	, ,1170-00	,		
21th surface									
	55	k = -1.090							
k = -0.990		A4 = -7.88092	2e-04, A6 = -1	1.01703e-	-05, A8 = 3.8	33265e-07	'		
A4 = -3.54488e - 02, $A6 = 4.28101e - 03$, $A8 = -2.94472e - 04$,		15th surface							
A10 = 1.55285e-05		k = -24.035							
Various data	•	A4 = 8.255936	e-05, A6 = 1.5	3390e-06	6, A8 = -6.89	536e-09			
	— 60	16th surface							
NA 0.75		1 2001							
Magnification -4.18		k = -3.821	0- 05 46 1	01104 0	7 40 1 40	MAT - AT			
Focal length 1.99 Image height (mm) 2.30		A4 = -3.09218	se-05, A6 = 1.	81194e-0	0/, A8 = 1.48	su21e-07			
Image height (mm) 2.30 fb (mm) (in air) 3.74		17th surface							
Lens total length (mm) (in air) 30.73	65	k = -0.514							

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		Milling	eu .						Milling			
		Unit mm				_			Unit mm			
18th surface						_ 5						
k = -0.768							24	œ	0.38	1.51640	65.06	0.535
	e-03, A6 = -1.	53083e=0	04 A8 = 1.20	068e-06			25	∞	0.45			
19th surface	,		,				Image	∞				
						_	plane					
k = 0.112 A4 = 3.023366 20th surface	e-03, A6 = -1.	.24246e-()4, A8 = 1.29	603e-06		10 _	piane	7	/arious da	to		
k = -105.496						- -		``	arious ua	ia.		
	e-04, A6 = -2.	.00034e-0	04, A8 = 6.78	493e-06,			NA				0.39	
A10 = -2.0903 21th surface	10e-07					15	Magni	ification			-2.04	
21th surface						-	Focal	length			10.15	
k = -0.635								height (mm)			2.82	
	8e-04, A6 = -4	4.19913e-	-07, A8 = -1	.09125e-0	06,		-				4.84	
A10 = 1.63697	/e-08					30	,	n) (in air)	N // 11			
22th surface						_ 20 _	Lens t	otal length (mr	n) (ın air)		54.88	
k = -1.372 A4 = -4.25916	6e-03, A6 = 3.	.29135e-(05, A8 = 1.23	251e-05.		_						
A10 = -3.4489			,	.,								
23th surface						- ₂₅		Ez	kample	91		
k = -0.921						23						
	9e-02, A6 = 1.	.80785e-0	3, A8 = -2.7	7502e-05	5,							
A10 = -3.4804	41e-06					_						
	V	⁄arious dat	ta			30 _			Unit mm			
NA				0.95		_ 50 _		S	urface da	ta		
_	fication			-8.37		_	Surface no.	_	d	nd	ard	Act
Focal l	-			2.62		_	Surface no.	r	a	nd	νd	θgf
	height (mm) n) (in air)			2.30 15.35			1	-10.000	4.63	2.00100	29.13	0.60
	n) (in air) otal length (mn	n) (in air)		52.72		35	2	18.300	3.42	1.90366	31.32	0.59
2.215 ((-, (mr)				_	3	-9.713	0.10	1.04655	22.50	0
							4 5	14.345 -82.083	2.73 3.46	1.84666	23.78	0.62
							6	12.268	2.91	1.49700	81.61	0.53
	Ex	kample	90			40	7	-11.850	1.47	1.72916	54.68	0.54
			-			40	8	-10.000	0.50	1.76182	26.52	0.61
							9	9.606	2.02			
						_	10 (Stop)	oo 50,073	0.10	1.04666	22.50	0.00
		Unit mm				_	11 12	59.973 7.193	0.50 2.80	1.84666 1.65160	23.78 58.55	0.62
							13	-15.686	0.10	1.03100	دد.ەد	0.54
	S	urface dat	ta			4 5	14	7.063	3.37	1.49700	81.61	0.53
Surface no.	r	d	nd	vd	θgf		15	-11.667	0.75			
ourrace IIO.	1	u	щ	vu	ogı	_	16	-9.306	5.00	1.63980	34.46	0.59
1	-10.000	5.00	2.00100	29.13	0.600		17	6.435	4.14	2.00100	20.12	0.00
2	14.403	4.74	1.90366	31.32	0.595		18	19.482 -12.687	2.64 1.49	2.00100	29.13	0.60
	-10.848 19.239	0.13	1 84666	22.70	0.620	50	19 20	-12.687 -10.019	0.50	1.43875	94.93	0.53
3	-35.634	3.06 2.85	1.84666	23.78	0.620		20	6.821	0.73	1.7JUIJ	√ 7. 23	0.55
3 4		2.97	1.49700	81.61	0.538		22	7.316	5.00	2.00100	29.13	0.60
3	11.706	1.87	1.72916	54.68	0.544		23	8.425	4.00			
3 4 5 6 7	11.706 -23.462		1.76182	26.52	0.613		24	œ	0.30	1.51640	65.06	0.53
3 4 5 6 7 8	11.706 -23.462 -10.000	0.50				55	25	œ	0.36			
3 4 5 6 7 8 9	11.706 -23.462 -10.000 8.807	2.18										
3 4 5 6 7 8 9 10 (Stop)	11.706 -23.462 -10.000		1.84666	23.78	0.620		Image	8				
3 4 5 6 7 8 9 10 (Stop) 11	11.706 -23.462 -10.000 8.807 ∞ 160.537 7.000	2.18 0.10 0.50 2.91	1.84666 1.65160	23.78 58.55	0.620 0.542		Image plane	∞				
3 4 5 6 7 8 9 10 (Stop) 11 12	11.706 -23.462 -10.000 8.807 160.537 7.000 -17.489	2.18 0.10 0.50 2.91 0.10	1.65160	58.55	0.542	_			- · ·			
3 4 5 6 7 8 9 10 (Stop) 11 12 13	11.706 -23.462 -10.000 8.807 160.537 7.000 -17.489 6.830	2.18 0.10 0.50 2.91 0.10 3.73				_			⁄arious da	ta		
3 4 5 6 7 8 9 10 (Stop) 11 12 13 14 15	11.706 -23.462 -10.000 8.807 160.537 7.000 -17.489 6.830 -12.198	2.18 0.10 0.50 2.91 0.10 3.73 0.82	1.65160 1.49700	58.55 81.61	0.542 0.538	- 60 -	plane		⁄arious da	ta	0.41	
3 4 5 6 7 8 9 10 (Stop) 11 12 13 14 15 16	11.706 -23.462 -10.000 8.807 160.537 7.000 -17.489 6.830	2.18 0.10 0.50 2.91 0.10 3.73	1.65160	58.55	0.542	_	plane NA	V	⁄arious da	ta	0.41	
3 4 5 6 7 8 9 10 (Stop) 111 12 13 14 15 16 17 18	11.706 -23.462 -10.000 8.807 ∞ 160.537 7.000 -17.489 6.830 -12.198 -8.988 8.015 30.017	2.18 0.10 0.50 2.91 0.10 3.73 0.82 2.29 2.84 3.00	1.65160 1.49700	58.55 81.61	0.542 0.538	_	plane NA Magni	Vification	⁄arious da	ta	-2.04	
3 4 5 6 7 8 9 10 (Stop) 11 12 13 14 15 16 17 18	11.706 -23.462 -10.000 8.807 160.537 7.000 -17.489 6.830 -12.198 -8.988 8.015 30.017 -9.829	2.18 0.10 0.50 2.91 0.10 3.73 0.82 2.29 2.84 3.00 4.23	1.65160 1.49700 1.72825 1.84666	58.55 81.61 28.46 23.78	0.542 0.538 0.608 0.620	_	plane NA Magni Focal	Vification length	⁄arious da	ta	-2.04 9.96	
3 4 5 5 6 6 7 8 9 10 (Stop) 11 12 13 14 15 16 17 18 19 20	11.706 -23.462 -10.000 8.807 50 160.537 7.000 -17.489 6.830 -12.198 -8.988 8.015 30.017 -9.829 -6.731	2.18 0.10 0.50 2.91 0.10 3.73 0.82 2.29 2.84 3.00 4.23 0.50	1.65160 1.49700 1.72825	58.55 81.61 28.46	0.542 0.538 0.608	_	plane NA Magni Focal Image	Vification	∕arious da	ta	-2.04	
3 4 5 6 7 8 9 10 (Stop) 11 12 13	11.706 -23.462 -10.000 8.807 160.537 7.000 -17.489 6.830 -12.198 -8.988 8.015 30.017 -9.829	2.18 0.10 0.50 2.91 0.10 3.73 0.82 2.29 2.84 3.00 4.23	1.65160 1.49700 1.72825 1.84666	58.55 81.61 28.46 23.78	0.542 0.538 0.608 0.620	_	plane NA Magni Focal Image fb (mr	tification length height (mm)			-2.04 9.96 2.25	

251 Example 92

252 -continued

Surface no. r d nd vd 0gf 1 1 -10,000 5,49 2,00100 29,13 0,600 2 1 0,500 1 0,5											Unit mm			
Surface no.			Unit mm				- 5				0.30	1.51640	65.06	0.535
Surface no.		S					- ´		plane		0.35			
1	rface no.				vd	θgf	-				Various dat	ta		
TRAST							10		Magnific				0.40 -2.04	
6 11.573 2.73 1.49700 81.61 0.538	ļ	78.347	5.54	1.84666	23.78	0.620			Image he	eight(mm)		9.83 2.25 4.55	
8	i	11.573	2.73	1.49700	81.61	0.538					mm) (in air)		52.90	
11(Step)	; •	14.320 -10.443	4.05 0.50				15							
13											Example	94		
14											_			
15				1.39322	07.74	0.344	20							
17		14.276	2.92	1.49700	81.61	0.538	20							
18				1.40700	Q1 61	0.538					Unit mm			
20				1.49700	81.01	0.556					Surface dat	ta		
21)	22.042	2.17	1.84666	23.78	0.620		G			ı	4	1	0-6
22				2.00100	20.12	0.600	25	Surface no.		r	d	nd	νd	θgf
Table Tabl				2.00100	29.13	0.000						1.84666	23.78	0.620
Timage plane				1.51640	65.06	0.535						1 04666	22.70	0.630
NA			0.36									1.84000	23.78	0.620
NA	age plane	œ						5				1.49700	81.61	0.538
NA		7	Various dat	ta			30							
Magnification							-						55.53 29.23	0.543
Focal length Focal length Focal length Image height(mm) In air) Lens total length(mm) (in air) Example 93 Example 93 Example 93 Example 93 Unit mm Surface no. r d nd vd degf 1 1 -10.032 4.92 2.00100 29.13 0.600 2 19.888 3.27 1.90366 31.32 0.595 3 -9.704 0.10 4 14.300 2.59 1.84666 23.78 0.620 5 -9.5704 3.79 6 13.188 2.70 1.49700 81.61 0.538 7 -11.814 1.46 1.72916 54.68 0.544 8 -10.000 0.50 1.76182 26.52 0.613 9 9 9.651 1.97 10(Stop) 0 0.76 11 57.750 0.50 1.84666 23.78 0.620 12 7.886 2.63 1.65160 58.55 0.542 13 -15.437 0.10 14 6.888 3.22 1.49700 81.61 0.538 15 -12.109 0.76 16 -9.386 5.00 1.64394 31.87 0.599 60 Unit mm 10(Stop) 0 0.96 11 -1.31.688 0.50 1.84666 2.378 0.620 12 7.886 2.63 1.65160 58.55 0.542 13 -15.437 0.10 14 6.888 3.22 1.49700 81.61 0.538 15 -12.109 0.76 16 -9.386 5.00 1.64394 31.87 0.599 60 Unit mm 10(Stop) 0 0.96 11 -1.31.688 0.50 1.84666 2.378 0.620 12 0 0.9569 0.50 1.64394 31.87 0.599 60 Unit mm 10(Stop) 0 0.96 11 -1.31.688 0.50 1.84666 2.378 0.620 12 0.886 0.23 1.65160 58.55 0.542 13 -15.437 0.10 14 6.888 3.22 1.49700 81.61 0.538 15 -12.109 0.76 16 -9.386 5.00 1.64394 31.87 0.599		nification										1.72131	29.23	0.003
Image height(mm)														
Lens total length(mm) (in air) 79.91 13													23.78	0.620
Example 93 Lange Parish Parish							35					1.59522	67.74	0.544
	Lens	total length(mn	n) (in air)		79.91							1.49700	81.61	0.538
Example 93 Color							_		-			1.42700	01.01	0.550
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$									-			1.49700	81.61	0.538
Surface no. r d nd vd θgf		Es	vommla i	02								1.04666	22.70	0.630
Unit mm Surface no. r d nd vd θgf		E	xampie	93			40					1.84000	23.78	0.620
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$												2.00100	29.13	0.600
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$														
Surface data Timage plane			I Init mm				-					1.51640	65.06	0.535
Surface no. r d nd vd θgf 1 -10.032 4.92 2.00100 29.13 0.600 Magnification -2 2 19.088 3.27 1.90366 31.32 0.595 50 3 -9.704 0.10 50 1.84666 23.78 0.620 5 -95.704 3.79 3.79 1.49700 81.61 0.538 1.50 1.70 1.60 1.72 1.61 0.538 0.544 1.88 -10.000 0.50 1.76182 26.52 0.613 9 9.651 1.97 55 1.96 1.84666 23.78 0.620 1.76182 26.52 0.613 9 9.651 1.97 55 55 1.76182 26.52 0.613 9 1.7886 2.63 1.65160 58.55 0.542 1.5 1.5 1.5437 0.10 1.64394 31.87 0.599 60 Unit mm Unit mm			OHIT HIH				_		e		0.36			
Surface no. r d nd vd θgf 1 -10.032 4.92 2.00100 29.13 0.600 Magnification - 2 19.088 3.27 1.90366 31.32 0.595 Focal length - 3 -9.704 0.10 50 Image height(mm) Image height(mm) th(mm) (in air) 10 mage height(mm) t		S	Surface dat	ta			4 5	- Image pran						
1	Surface no.	r	d	nd	vd	θgf					Various dat	ta		
2 19.088 3.27 1.90366 31.32 0.595 Focal length 3 -9.704 0.10 4 14.300 2.59 1.84666 23.78 0.620 5 -95.704 3.79 6 13.188 2.70 1.49700 81.61 0.538 7 -11.814 1.46 1.72916 54.68 0.544 8 -10.000 0.50 1.76182 26.52 0.613 9 9 9.651 1.97 10(Stop)	1	-10.032	4.92	2.00100	29 13	0.600	_			ation			0.69	
3		19.088											-4.09 6.84	
5	3						50)		2.25	
6 13.188 2.70 1.49700 81.61 0.538 7 -11.814 1.46 1.72916 54.68 0.544 8 -10.000 0.50 1.76182 26.52 0.613 9 9.651 1.97 55 10(Stop) ∞ 0.10				1.84666	23.78	0.620							5.02	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				1.49700	81 61	0.538			Lens tota	ıl length(mm) (in air)		79.91	
8								_						
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				1.76182		0.613								
11 57.750 0.50 1.84666 23.78 0.620 12 7.886 2.63 1.65160 58.55 0.542 13 -15.437 0.10 14 6.898 3.22 1.49700 81.61 0.538 15 -12.109 0.76 16 -9.386 5.00 1.64394 31.87 0.599 60 Unit mm							55				D 1	0.5		
12 7.886 2.63 1.65160 58.55 0.542 13 -15.437 0.10 14 6.898 3.22 1.49700 81.61 0.538 15 -12.109 0.76 16 -9.386 5.00 1.64394 31.87 0.599 60 Unit mm				1.84666	23.78	0.620					⊏xample	93		
14 6.898 3.22 1.49700 81.61 0.538 15 -12.109 0.76 16 -9.386 5.00 1.64394 31.87 0.599 60 Unit mm	12													
15 -12.109 0.76 16 -9.386 5.00 1.64394 31.87 0.599 60 Unit mm				1 105	0.1	0.55-								
16 -9.386 5.00 1.64394 31.87 0.599 60				1.49700	81.61	0.538					T T '*			
				1.64394	31.87	0.599	60				∪nıt mm			
	17	6.269	4.13								Surface dat	ta		
18 19.105 2.59 1.96066 27.70 0.596				1.96066	27.70	0.596		g c				-	-	
19 -12.400 1.79 Surface no. r d nd 20 -9.554 0.50 1.43875 94.95 0.545				1 43875	94 05	0.545		Surface no.		r	d	nd	vd	θgf
21 6.985 0.72 1 -7.000 2.11 1.53368				1.730/3	ノマ・フリ	v.∋ + J		1	_	7.000	2.11	1.53368	55.90	0.563
22 7.392 5.00 2.00100 29.13 0.600 ⁶⁵ 2* -5.323 0.10	22	7.392	5.00	2.00100	29.13	0.600	65	2*	-	-5.323	0.10			
23 8.938 4.00 3* 22.215 2.37 1.84666	23	8.938	4.00					3*	2	2.215	2.37	1.84666	23.77	0.620

254 Example 96

k = A4 3rd k = A4	-9.110 -5.145 -11.263 -11.263 91.067 83.446 -4.282 -10.570 -11.698 10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	Unit n 2.81 0.50 0.00 0.20 0.65 2.36 0.70 0.10 1.06 0.70 2.92 0.05 3.56 2.76 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30 Otherical su	1.60999 1001.00000 1.63762 1.61800 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	27.48 -3.45 34.21 63.33 34.71 34.71 63.33 81.61 30.30 23.88 55.90 65.06	0.620 0.296 0.594 0.544 0.583 0.543 0.544 0.538 0.544 0.538 0.599 0.630 0.563	5 10 15		r -7.000 -5.934 33.139 -9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	Unit mm d 2.16 0.10 2.32 0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70 0.10		vd 55.90 23.77 81.61 27.48 -3.45 34.21 63.33 34.71	θgf 0.563 0.620 0.538 0.620 0.296 0.594 0.544 0.583
5 6 7 8 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane 2nc k = A4 3rd	-5.145 -11.263 -11.263 91.067 83.446 -4.282 -10.570 -11.698 10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216 Aspend surface = 0.000	0.50 0.00 0.20 0.65 2.36 0.70 0.10 1.06 0.70 2.92 0.05 3.56 2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.61800 1.63762 1.61800 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	-3.45 34.21 63.33 34.71 34.71 63.33 81.61 30.30 23.88 55.90	0.296 0.594 0.544 0.583 0.544 0.538 0.599 0.630 0.563	10	1 2* 3* 4 5 6 7 8 9 10 11 12 13 14 (Stop)	r -7.000 -5.934 33.139 -9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	Surface de d 2.16 0.10 2.32 0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70	nd 1.53368 1.84666 1.49700 1.60999 1001.00000 1.63762 1.61800	55.90 23.77 81.61 27.48 -3.45 34.21 63.33	0.563 0.620 0.538 0.620 0.296 0.594
6 7 8 9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane	-11.263 -11.263 -11.263 91.067 83.446 -4.282 -10.570 -11.698 10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	0.00 0.20 0.65 2.36 0.70 0.10 1.06 0.70 2.92 0.05 3.56 2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10	1.61800 1.63762 1.61800 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	-3.45 34.21 63.33 34.71 34.71 63.33 81.61 30.30 23.88 55.90	0.296 0.594 0.544 0.583 0.544 0.538 0.599 0.630 0.563	15	1 2* 3* 4 5 6 7 8 9 10 11 12 13 14 (Stop)	r -7.000 -5.934 33.139 -9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	d 2.16 0.10 2.32 0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70	nd 1.53368 1.84666 1.49700 1.60999 1001.00000 1.63762 1.61800	55.90 23.77 81.61 27.48 -3.45 34.21 63.33	0.563 0.620 0.538 0.620 0.296 0.594
8 9 10 11 11(Stop) 13 14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane	-11.263 91.067 83.446 -4.282 -10.570 -11.698 10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	0.65 2.36 0.70 0.10 1.06 0.70 2.92 0.05 3.56 2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.63762 1.61800 1.72047 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	63.33 34.71 34.71 63.33 81.61 30.30 23.88 55.90	0.544 0.583 0.583 0.544 0.538 0.599 0.630 0.563	15	1 2* 3* 4 5 6 7 8 9 10 11 12 13 14 (Stop)	r -7.000 -5.934 33.139 -9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	d 2.16 0.10 2.32 0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70	nd 1.53368 1.84666 1.49700 1.60999 1001.00000 1.63762 1.61800	55.90 23.77 81.61 27.48 -3.45 34.21 63.33	0.563 0.620 0.538 0.620 0.296 0.594
9 10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane	83.446 -4.282 -10.570 -11.698 10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	2.36 0.70 0.10 1.06 0.70 2.92 0.05 3.56 2.54 1.66 2.70 0.50 2.69 0.50 1.10 0.30	1.72047 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	34.71 63.33 81.61 30.30 23.88 55.90	0.583 0.583 0.544 0.538 0.599 0.630 0.563	15	1 2* 3* 4 5 6 7 8 9 10 11 12 13 14 (Stop)	-7.000 -5.934 33.139 -9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	2.16 0.10 2.32 0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70	1.53368 1.84666 1.49700 1.60999 1001.00000 1.63762 1.61800	55.90 23.77 81.61 27.48 -3.45 34.21 63.33	0.563 0.620 0.538 0.620 0.296 0.594
10 11 12(Stop) 13 14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane	-4.282 -10.570 -11.698 10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216 Aspend surface = 0.000	0.70 0.10 1.06 0.70 2.92 0.05 3.56 2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30	1.72047 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	34.71 63.33 81.61 30.30 23.88 55.90	0.583 0.583 0.544 0.538 0.599 0.630 0.563	15	2* 3* 4 5 6 7 8 9 10 11 12 13 14 (Stop)	-5.934 33.139 -9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	0.10 2.32 0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70	1.84666 1.49700 1.60999 1001.00000 1.63762 1.61800	23.77 81.61 27.48 -3.45 34.21 63.33	0.620 0.538 0.620 0.296 0.594 0.544
12(Stop) 13 14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane	~ 11.698 10.934 10.934 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	1.06 0.70 2.92 0.05 3.56 2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	63.33 81.61 30.30 23.88 55.90 55.90	0.544 0.538 0.599 0.630 0.563	15	3* 4 5 6 7 8 9 10 11 12 13 14 (Stop)	33.139 -9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	2.32 0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70	1.49700 1.60999 1001.00000 1.63762 1.61800	81.61 27.48 -3.45 34.21 63.33	0.538 0.620 0.296 0.594 0.544
13 14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane	-11.698 10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	0.70 2.92 0.05 3.56 2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	63.33 81.61 30.30 23.88 55.90 55.90	0.544 0.538 0.599 0.630 0.563		4 5 6 7 8 9 10 11 12 13 14 (Stop)	-9.292 -191.804 -17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	0.10 1.74 2.00 0.50 0.00 0.20 0.72 2.34 0.70	1.49700 1.60999 1001.00000 1.63762 1.61800	81.61 27.48 -3.45 34.21 63.33	0.538 0.620 0.296 0.594 0.544
14 15 16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane	10.934 -10.364 10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	2.92 0.05 3.56 2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	63.33 81.61 30.30 23.88 55.90 55.90	0.544 0.538 0.599 0.630 0.563		6 7 8 9 10 11 12 13 14 (Stop)	-17.291 -5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	2.00 0.50 0.00 0.20 0.72 2.34 0.70	1.60999 1001.00000 1.63762 1.61800	27.48 -3.45 34.21 63.33	0.620 0.296 0.594 0.544
16* 17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane 2nd k = A4 3rd	10.909 -11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216 Aspend surface = 0.000	3.56 2.54 1.66 4.73 2.76 0.50 2.69 0.50 1.10 0.30 0.30	1.58364 1.63490 1.53368 1.53368 1.51640	30.30 23.88 55.90 55.90	0.599 0.630 0.563 0.563		7 8 9 10 11 12 13 14 (Stop)	-5.386 -11.263 -11.263 23.280 30.025 -4.979 -10.584	0.50 0.00 0.20 0.72 2.34 0.70	1001.00000 1.63762 1.61800	-3.45 34.21 63.33	0.296 0.594 0.544
17* 18* 19* 20* 21 22 23 24 25* 26 27 Image plane 2nd k = A4 3rd	-11.347 10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216 Aspend surface = 0.000	2.54 1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.58364 1.63490 1.53368 1.53368 1.51640	30.30 23.88 55.90 55.90	0.599 0.630 0.563 0.563		8 9 10 11 12 13 14 (Stop)	-11.263 -11.263 23.280 30.025 -4.979 -10.584	0.00 0.20 0.72 2.34 0.70	1001.00000 1.63762 1.61800	-3.45 34.21 63.33	0.296 0.594 0.544
18* 19* 20* 21 22 23 24 25* 26 27 Image plane 2nd k = A4 3rd	10.087 7.386 13.468 -20.719 127.874 4.905 -6.683 42.216 Aspend surface = 0.000	1.66 4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.63490 1.53368 1.53368 1.51640	23.88 55.90 55.90	0.630 0.563 0.563	20	10 11 12 13 14 (Stop)	23.280 30.025 -4.979 -10.584	0.72 2.34 0.70	1.61800	63.33	0.544
19* 20* 21 22 23 24 25* 26 27 Image plane 2nc k = A4 3rd	7.386 13.468 -20.719 127.874 4.905 -6.683 42.216	4.73 2.76 2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.63490 1.53368 1.53368 1.51640	23.88 55.90 55.90	0.630 0.563 0.563	20	11 12 13 14 (Stop)	30.025 -4.979 -10.584	2.34 0.70			
21 22 23 24 25* 26 27 Image plane 2no k = A4 3rd	-20.719 127.874 4.905 -6.683 42.216	2.70 0.50 2.69 0.50 1.10 0.30 0.30	1.53368 1.53368 1.51640	55.90 55.90	0.563 0.563	20	12 13 14 (Stop)	-4.979 -10.584	0.70			
22 23 24 25* 26 27 Image plane 2no k = A4 3rd	127.874 4.905 -6.683 42.216 Asp and surface = 0.000	0.50 2.69 0.50 1.10 0.30 0.30	1.53368 1.51640	55.90	0.563	20	14 (Stop)		0.10			
23 24 25* 26 27 Image plane 2no k = A4 3rd	4.905 -6.683 42.216 \$\infty\$ \$\infty\$ Asp and surface	2.69 0.50 1.10 0.30 0.30	1.53368 1.51640	55.90	0.563	20		co.				
24 25* 26 27 Image plane 2nd k = A4 3rd	-6.683 42.216	0.50 1.10 0.30 0.30	1.51640				15	-11.693	1.07 0.70	1.72047	34.71	0.583
25* 26 27 Image plane 2nc k = A4 3rd A4 A4	42.216	1.10 0.30 0.30	1.51640				16	12.173	2.75	1.61800	63.33	0.544
26 27 Image plane 2nc k = A4 3rd k = A4	∞ ∞ ∞ ∞ Aspend surface = 0.000	0.30 0.30		65.06			17	-10.862	0.05			
2nd k = A4 3rd k = A4	Asp and surface = 0.000		unfo o o dete		0.535		18* 19*	10.882	3.39	1.49700	81.61	0.538
2nd k = A4 3rd k = A4	Asp and surface = 0.000	herical su	urfo o o distri			25	20*	-11.666 8.928	2.60 1.63	1.58364	30.30	0.599
k = A4 3rd k = A4	and surface = 0.000	herical su	urfaca disti			23	21*	6.663	4.22	1100001	00.00	0.000
k = A4 3rd k = A4	and surface = 0.000	herical su				•	22*	12.130	2.64	1.63490	23.88	0.630
k = A4 3rd k = A4	= 0.000		rrace data				23 24	-24.243 -50.390	2.64 0.50	1.53368	55.90	0.563
k = A4 3rd k = A4	= 0.000						25	5.177	2.62	1.55500	33.70	0.505
A4 3rd k = A4						30	26	-6.111	0.50	1.53368	55.90	0.563
3rd k = A4	4 = 4.45010e						27* 28	–7309.424 ∞	1.10 0.30	1.51640	65.06	0.535
k = A4		-05					29	∞ ∞	0.30	1.51040	05.00	0.555
A4	d surface					-	Image plane	∞				
	= 0.000	0.5				35		Asphe	erical surf	ace data		
	4 = 8.14332e- 6th surface	-05						2nd surface				
1 ₅ _	= 0.000					-		k = 0.000				
	4 = -2.69612	-04						A4 = 2.52174e - 0	5			
	7th surface					40		3rd surface				
						-		k = 0.000				
	= 0.000							A4 = 8.68592e-0	5			
	4 = 9.67105e- 8th surface	-05						18th surface				
180	sui suitace					-		k = 0.000				
k =	= 0.000					45		A4 = -2.56350e - 19th surface	04			
A4	4 = -2.81280	e-05						19th surface				
<u>19t</u>	th surface					_		k = 0.000				
1-	0.000							A4 = 1.10244e - 0 20th surface	4			
	= 0.000 4 = 4.63309e-	-05				50		20th stillace				
	th surface	05				50		k = 0.000				
_						-		A4 = -1.71924e-	05			
k =	= 0.000							21th surface				
	4 = -7.88627	e-05						k = 0.000				
<u>25t</u>	5th surface					- 55		A4 = 4.70589e - 0	5			
k =	= 0.000							22th surface				
		e-03, A6	= -3.11735e-05					k = 0.000				
		Various	data			-		A4 = -4.16768e - $27th surface$	05			
		+ ar rous	uatu			60		k = 0.000				
NA Magn	nification			0.32 -2.00				A4 = -1.84423e	03, A6 = -	-2.68348e-05		
Focal	ıl length			3.75					Various da	ıta		
_	ge height(mm)		3.87								
	ım) (in air)	nm) (in a	ir)	1.60 39.89		65		NA Magnification			0.32 -2.00	
Lens		لة اللله (بيبيد	·· <i>)</i>	57.09		0.5		viagnification Focal length		-	3.71	

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Unit mm	
Image height(mm)	3.87
fb(mm) (in air)	1.60
Lens total length(mm) (in air)	39.90

Next, a lens which forms the lens unit Gf and a lens which forms the lens unit Gr are shown below.

	Lens unit Gf	Lens unit Gr	
Example1	L1~L5	L6~L10	
Example2	L1~L5	L6~L10	15
Example3	L1~L6	L7~L12	1.0
Example4	L1~L5	L6~L11	
Example5	L1~L5	L6~L8	
Example6	L1~L4	L5~L8	
Example7	L1~L4	L5~L8	

Next, values of conditional expressions (1) to (15) in each example are shown below. '-' (hyphen) indicates that there is no corresponding arrangement or conditional expression is not satisfied. Moreover, with respect to the example 6 and the example 7, since there is no pair of lenses which satisfy conditional expression (1) to (3), description for conditional expression (1) to (3) is omitted.

	Exam- ple1	Exam- ple2	Exam- ple3	Exam- ple4	Exam- ple5
$(1)\mathbf{r}_{OBf}/\mathbf{r}_{TLr}$					
r1, r21	-1	-1.085	_	_	_
r3, r19	-1	-1.010	_	_	_
r5, r17	-1	-0.952	_	_	-1
r7, r15	-1	-1.010	_	_	_
r9, r13	-1	-0.995	_	_	-1
r1, r25	_	_	-1	_	_
r3, r23	_	_	-1	_	_
r5, r21	_	_	-1	_	_
r7, r19	_	_	-1	_	_
r9, r17	_	_	-1	_	_
r11, r15	_	_	-1	_	_
r1, r23	_	_		-1	_
r5, r17	_	_		-1	_
r7, r15	_	_		-1	_
r9, r13	_	_	_	-1	_
$(2)\mathbf{r}_{OBr}/\mathbf{r}_{TLf}$					
r2, r20	-1	-0.995	_	_	_
r4, r18	-1	-1.001	_	_	_
r6, r16	-1	-0.952	_	_	-1
r8, r14	-1	-0.990	_	_	_
r10, r12	-1	-0.926	_	_	-1
r2, r24	_	_	-1	_	_
r4, r22	_	_	-1	_	_
r6, r20	_	_	-1	_	_
r8, r18	_	_	-1	_	
r10, r16	_	_	-1	_	_
r12, r14	_	_	-1		_
r2, r22	_	_	_	-1	_
r6, r16	_	_		-1	_
r8, r14	_	_	_	-1	_
r10, r12	_	_	_	-1	_

$(3)(d_{OB} - d_{TL})/(d_{OB} + d_{TL})$	Exam- ple1	Exam- ple2	Exam- ple3
d1, d20	0	-0.003	
d3, d18	0	-0.005	_
d5, d16	0	0.013	_
d7, d14	0	0.003	_
d9, d12	0	0.006	_

	P		P
d9, d12	_	_	_
d7, d14	_	_	_
d5, d16	_	_	_
d1, d22	_	_	_
d11, d17	_	_	0
d9, d17	_	_	0
d7, d19	_	_	0
d5, d20	_	_	0
d3, d22	_	_	0
d1, d24	_	_	0

$(3)(\mathrm{d}_{OB}-\mathrm{d}_{TL})/(\mathrm{d}_{OB}+\mathrm{d}_{TL})$	Exam- ple4	Exam- ple5
d1, d20	_	_
d3, d18	_	_
d5, d16	_	0
d7, d14	_	_
d9, d12	_	0
d1, d24	_	_
d3, d22	_	_
d5, d20	_	_
d7, d19	_	_
d9, d17	_	_
d11, d17	_	_
d1, d22	0	_
d5, d16	0	_
d7, d14	0	_
d9, d12	0	

	Exam- ple1	Exam- ple2	Exam- ple3	Exam- ple4	Exam- ple5
(4)NA	0.25	0.25	0.25	0.25	0.25
NA'	0.25	0.25	0.25	0.25	0.15
(5)β	-1.00	-0.99	-1.00	-1.00	-1.68
$(6)f_{OB}/f_{TL}$	1.00	1.01	1.00	1.00	0.60
(9)d ₁ /Σd	0.006	0.006	0.009	0.006	0.005
$(7)MTF_{OB}$	66	64	62	60	64
$(8)MTF_{TL}$	66	64	62	67	67
$(10)d_2/\Sigma d$	1.35	1.35	1.28	1.33	1.26
(11)∆f/Y	0.0004	-0.0041	-0.0047	-0.0007	-0.0008
$(12)\theta_o$	0.4	0.4	1.6	0.9	2.2
$(13)\Delta f_{cd}/\epsilon d$	8.40	9.90	11.20	7.70	1.70
$(14)d_{SHOB}/d_{SHTL}$	1.00	0.99	1.00	0.97	0.71

	Exam- ple6	Exam- ple7
(4)NA	0.22	0.17
NA'	0.17	0.22
(5)β	-1.27	-0.79
$(6)f_{OB}/f_{TL}$	0.79	1.27
(9)d₁/Σd	0.024	0.024
$(7)MTF_{OB}$	61	66
$(8)MTF_{TL}$	66	61
$(10)d_2/\Sigma d$	0.38	0.38
$(11)\Delta f/Y$	-0.0047	-0.0058
$(12)\theta_o$	28.4	25.3
$(13)\Delta f_{cd}/\epsilon d$	2.50	2.50
$(14)d_{SHOB}/d_{SHTL}$	0.88	1.13

Also, values of fc/4 and fc'/4 in each example are shown below.

	Exam-	Exam-	Exam-	Exam-	Exam-
	ple1	ple2	ple3	ple4	ple5
Fc/4	229	229	229	229	229
Fc/4'	229	232	229	229	137
		Exam- ple6		Exam- ple7	
_	Fc/4 Fc/4'		201 159		

Next, values of conditional expressions (15) to (57) in each
example are given below. '-' (hyphen) indicates that there is
no corresponding arrangement or conditional expression is
not satisfied.

example a	ire given be	elow. '-'	hyphen) in	ndicates th	hat there is							
					pression is		(51)	0.06	0.05	0.05	0.05	0.05
		rangemei	n or cond	monai ex	Pression 18		(53)	0.07	0.09	0.03	0.05	0.03
not satisfic	ea.						(54)	0.80	0.80	0.80	0.80	0.84
						5	(55)	0.35	0.53	0.35	0.35	0.45
							(56)	0.92	0.91	0.92	0.92	1.07
(15) (15	5-1), (15-2)	β					(57)	0.85	0.49	0.82	0.92	-0.29
(16)	3 1), (13 2)	NA					(37)	0.63	0.49	0.62	0.67	-0.29
(17)			./2Y					P	E	P	E	E
(18)			$D_{G2dC} + (\Delta D_0)$	∨R 2	2/			Exam-	Exam-	Exam-	Exam-	Exam-
(16)						10		ple13	ple14	ple15	ple16	ple17
(19)			+ β _{G2C} × ΔD, D/BF	G1 <i>dC</i> (1G2 <i>C)))</i> /	ϵ_d	10	(1.5)	1.05	1.05	1.05	1.05	1.05
(20), (20	0.1)	2	(WD × tan(s	INTAN . X	7 1/4		(15)	-1.05	-1.05	-1.05	-1.05	-1.05
	0-1)			sin 'NA) + 1	$_{obj})/\Phi_s$		(16)	0.13	0.14	0.21	0.18	0.20
(21)		D_m	ax/Φ_s				(17)	3.5	3.7	4.5	4.4	4.1
(22)		D_G	$1max/\Phi_s$				(18)	6.04	6.34	10.28	8.68	11.52
(23), (23)		L_L	\mathcal{D}_{oi}				(19)	7.28	7.67	4.83	3.95	4.59
(24), (24)	4-1)	1/v	d_{min} -1/ νd_{max}			15	(20)	4.19	3.70	2.57	3.46	3.09
(25), (25)	5-1)		$_{i}/\mathrm{D}_{oi}$				(21)	1.01	0.75	0.66	1.30	1.03
(26)		ϕ_{G}	$_{to}/(2 \times Y/ \beta)$				(22)	0.08	0.11	0.34	0.02	0.24
(27)		BF.	/L _{1.}				(23)	0.57	0.55	0.68	0.64	0.60
(28)		BF					(24)	0.03	0.03	0.03	0.03	0.02
(29)			$_{1o}/\mathrm{R}_{G1o}$				(25)	0.65	0.68	0.54	0.54	0.56
(30)			$_{1G2}/\Phi_s$				(26)	1.20	1.32	1.47	1.36	1.52
(31), (31	1-1)		$_{1}^{1}/L_{G2}$			20	(27)	0.09	0.10	0.08	0.11	0.12
(32)	1 1)		$^{1/L_{G2}}_{1s}/L_{sG2}$									0.12
							(28)	0.59	0.64	0.67	0.88	
(33)			1max ФG2max				(29)	0.24	0.26	0.79	0.29	0.47
(34)			L_{G1}				(30)	0.35	0.33	0.66	0.37	0.41
(35)			NP/Y				(31)	0.84	0.98	0.67	0.65	0.60
(36)			Aobj/CRAims	3		25	(32)	0.88	1.03	0.66	0.67	0.62
(37), (3'		f_{G1}	o/f			23	(33)	1.28	1.47	1.06	1.14	1.31
(38), (38	8-1)	R_G	10/WD				(34)	2.60	2.61	2.19	2.23	2.68
(39)		R_G	_{2i} /BF				(35)	5.88	6.91	6.85	6.30	5.97
(40)		R_G	$_{1\it{i}}/{ m D}_{G1\it{i}\it{s}}$				(36)	0.21	0.19	0.22	0.27	0.27
(41)			f_{G1}				(37)	2.08	1.93	6.36	5.23	2.43
(42)			d_{G1min} -1/ νd_G	21			(38)	2.27	1.99	1.09	2.62	1.52
(43)			d_{G2min} -1/ vd_{G}			30	(39)	6.50	9.05	12.80	3.25	156.92
(45)			$_{1s}/L_{G1s}$	32max		50	(40)	5.55	5.34	4.06	5.65	4.77
(47)			$_{oni}/\mathrm{L}_{G1s}$								4.43	1.81
(49)		D_n	mi ^{t L} G1s /T				(41)	1.54	1.55	3.77		
		D_{sl}	$_{OL}/\mathrm{L}_{sG2}$				(42)	0.03	0.03	0.03	0.03	0.02
(51)		D_n	$_{\rm ls}/{\rm D}_{os}$				(43)	0.03	0.03	0.02	0.02	0.02
(53)		D_{sn}	$_{i2}/\mathrm{D}_{si}$				(45)	1.00	1.00	1.00	1.00	_
(54)			$_{i3}$ / D_{si}			35	(47)	0.68	0.71	_	_	_
(55)			$_{2s}/\mathrm{D}_{os}$				(49)	_	_	_	_	_
(56)			$D_{oi} + 0.07 \times$				(51)	0.05	0.05	0.07	0.05	0.07
(57)		D_o	$L_{G1} - 0.39$:	× WD/BF			(53)	0.13	_	0.13	0.05	0.11
							(54)	0.85	0.84	0.88	0.84	0.84
	Exam-	Exam-	Exam-	Exam-	Exam-		(55)	0.41	0.41	0.50	0.48	0.41
	ple8	ple9	ple10	ple11	ple12	40	(56)	1.08	1.08	1.02	0.92	0.92
	•	-	•	•		40	(57)	-0.23	-0.38	0.31	0.69	0.89
(15)	-1.04	-1.05	-1.03	-1.03	-1.05		(/					
(16)	0.15	0.21	0.15	0.15	0.18			Exam-	Exam-	Exam-	Exam-	Exam-
(17)	3.6	4.2	3.6	3.6	3.6			ple18	ple19	ple20	ple21	ple22
(18)	10.74	11.51	9.01	10.78	8.52			Press	P	F	F	F
(19)	5.80	3.94	5.80	5.80	6.91		(15)	-1.04	-1.00	-1.33	-1.33	-1.33
(20)	3.54	2.91	3.64	3.64	2.93	45	(16)	0.15	0.15	0.23	0.23	0.23
(21)	1.18	0.92	1.21	0.98	0.53			3.6	4.3	3.7	6.1	4.5
(22)	0.25	0.44	0.21	0.23	0.05		(17)					
(22)	0.23	0.44	0.21	0.23	0.03		(18)	8.44	-1.96	3.68	4.38	7.50
		0.03	0.02	0.02			(19)	5.80	14.66	7.34	15.71	20.84
(24)	0.02				0.03		(20)	2.91	3.25	2.49	2.51	2.23
(25)	0.64	0.62	0.64	0.64	0.66		(21)	0.60	0.78	1.02	1.96	0.56
(26)	1.36	1.62	1.37	1.43	1.42	50	(22)	0.02	0.50	0.13	0.01	0.07
(27)	0.14	0.12	0.14	0.14	0.09		(23)	0.51	0.58	0.69	0.65	0.58
(28)	0.88	0.88	0.88	0.88	0.59		(24)	0.02	0.02	0.03	0.03	0.03
(29)	0.64	0.61	0.65	0.90	0.14		(25)	0.63	0.66	0.54	0.52	0.62
(30)	0.39	0.38	0.37	0.29	0.29		(26)	1.37	1.48	1.57	2.47	2.48
(31)	0.75	1.06	0.76	0.71	1.00		(27)	0.14	0.05	0.05	0.03	0.03
(32)	0.79	1.06	0.79	0.75	1.07	55	(28)	0.88	0.38	0.38	0.39	0.29
(33)	1.61	1.51	1.66	1.54	1.59	55	(29)	0.64	0.92	0.35	0.49	0.23
(34)	3.11	2.03	3.08	3.13	2.40							
(35)	5.50	11.95	5.85	6.43	6.26		(30)	0.60	0.24	0.42	0.29	0.07
		0.13	0.24	0.43	0.20		(31)	0.55	0.76	0.63	0.37	0.55
(36)	0.25						(32)	0.74	0.82	0.65	0.39	0.59
(37)	2.64	2.49	2.54	2.11	2.29		(33)	1.74	1.56	1.21	1.32	1.85
(38)	0.80	1.46	0.80	0.60	4.80	60	(34)	3.93	2.71	2.19	3.11	3.07
(39)	1152.63	3.92	-13.88	4.67	19.69		(35)	5.45	8.40	5.33	6.28	5.18
(40)	5.35	5.59	5.98	6.35	4.24							
(41)	1.78	1.85	1.69	1.65	1.46		(36)	0.22	0.18	0.21	0.21	0.26
(42)	0.02	0.02	0.02	0.02	0.03		(37)	2.48	7.65	2.11	2.30	3.80
(43)	0.02	0.02	0.02	0.02	0.03		(38)	0.80	0.57	2.38	1.24	0.66
(45)		_	_	_	1.00		(39)	-3.99	29134.52	-37.68	8.81	-14.44
					0.70	65	(40)	2.83	13.46	6.90	5.27	15.92
(47)												
(47)	_	_										
(47)	_	_	_	_	_		(41)	1.25	4.74	1.03	1.73	2.37

			59 tinued				-continued					
(42)	0.02	0.02	0.03	0.03	0.03	-	(37)	6.81	6.71	6.11	7.21	4.16
(43)	0.02	0.02	0.03	0.03	0.02		(38)	1.63	1.60	1.23	1.06	0.72
(45) (47)	_	1.00 0.77	1.00 0.61	1.00 0.71	1.00 0.73	5	(39) (40)	10.52 185.32	9.98 -988.41	11.07 -327.47	16.38 40.51	-2.99 49.74
(49)	_	_	_	_	_		(41)	2.91	2.82	2.61	3.98	3.64
(51) (53)	0.11 0.04	0.05 0.03	0.07 0.09	0.05 0.04	0.04 0.02		(42) (43)	0.03 0.02	0.03 0.02	0.03 0.02	0.03 0.02	0.03 0.02
(54)	0.80	0.92	0.92	0.96	0.95		(45)	1.00	1.00	1.00	1.00	1.00
(55) (56)	0.34 0.92	0.40 1.61	0.50 1.20	0.35 1.75	0.35 2.03	10	(47) (49)	_			_	_
(57)	1.67	-3.01	-0.67	-3.02	-5.05		(51) (53)	0.02 0.04	0.02 0.05	0.03 0.04	0.04 0.02	0.03 0.01
	Exam-	Exam-	Exam-	Exam-	Exam-	•	(54)	0.04	0.95	0.95	0.02	0.70
	ple23	ple24	ple25	ple26	ple27	_	(55) (56)	0.48 1.35	0.49 1.36	0.47 1.36	0.32 1.20	0.32 1.19
(15)	-1.33	-2.20	-2.55	-2.55	-2.55	15	(57)	-1.38	-1.42	-1.34	0.05	-0.05
(16) (17)	0.23 4.6	0.38 5.5	0.43 5.6	0.40 5.2	0.40 5.2		-	Exam-	Exam-	Exam-	Exam-	Exam-
(18)	4.83	7.31	8.28	15.29	15.98			ple33	ple34	ple35	ple36	ple37
(19) (20)	13.36 2.27	6.01 1.52	3.71 1.26	8.73 1.37	7.43 1.41		(15)	-1.33	-1.33	-1.33	-1.33	-1.33
(21)	0.66 0.01	0.74	1.04	0.86	0.93 0.03	20	(16)	0.23 4.5	0.23	0.23	0.23	0.23 5.0
(22) (23)	0.57	0.01 0.74	0.06 0.78	0.05 0.74	0.03		(17) (18)	7.72	4.7 2.62	4.8 3.45	4.9 4.97	2.00
(24) (25)	0.03 0.62	0.03 0.46	0.03 0.41	0.03 0.47	0.03 0.46		(19) (20)	5.75 2.35	12.05 2.55	10.55 2.55	4.40 2.53	13.69 2.56
(26)	2.49	3.73	3.70	4.37	4.38		(21)	0.64	0.89	0.88	0.86	0.89
(27) (28)	0.05 0.46	0.05 0.53	0.06 0.63	0.04 0.37	0.04 0.43	25	(22) (23)	0.01 0.52	0.16 0.72	0.16 0.72	0.15 0.69	0.14 0.73
(29)	0.46	0.57	0.03	0.37	0.43		(24)	0.03	0.72	0.03	0.03	0.73
(30) (31)	0.09 0.59	0.08 0.44	0.09 0.43	0.03 0.47	0.04 0.45		(25) (26)	0.64 2.57	0.54 1.78	0.54 1.81	0.54 1.83	0.53 1.83
(32)	0.63	0.46	0.44	0.46	0.45		(27)	0.13	0.03	0.03	0.08	0.03
(33) (34)	1.79 2.99	1.27 2.07	1.09 1.79	1.34 2.01	1.35 2.05	30	(28) (29)	1.06 0.94	0.27 0.43	0.31 0.42	0.75 0.37	0.24 0.39
(35)	5.53	5.31	4.99	4.22	4.18	50	(30)	0.06	0.26	0.37	0.38	0.37
(36) (37)	0.23 -48.46	0.16 3.89	0.14 3.89	0.20 5.56	0.18 6.66		(31) (32)	0.77 0.83	0.61 0.63	0.62 0.65	0.69 0.72	0.61 0.63
(38)	0.71	1.86	2.82	2.26	2.26		(33)	1.97	1.15	1.16	1.10	1.11
(39) (40)	-14.49 15.35	-1270.10 30.48	12.52 142.69	-12.86 -13851.56	-22.66 -953.80	35	(34) (35)	2.86 7.17	2.04 8.17	2.05 9.29	2.02 9.68	2.03 9.74
(41)	-29.10	1.39	1.22	2.03	2.35	33	(36)	0.20	0.14	0.13	0.15	0.16
(42) (43)	0.03 0.02	0.03 0.02	0.03 0.02	0.03 0.02	0.03 0.02		(37) (38)	4.03 0.67	1.99 1.88	1.95 1.98	1.58 2.27	1.63 2.15
(45)	0.96	1.00	1.00	1.00	1.00		(39)	4.67	20.40	13.06	3.44	84.44
(47) (49)	0.90	0.72	0.73	0.79	_	40	(40) (41)	14.22 2.63	8.78 1.14	6.88 1.15	7.05 1.19	6.82 1.15
(51)	0.04	0.05	0.05	0.02	0.02	40	(42)	0.03	0.03	0.03	0.03	0.03
(53) (54)	0.02 0.92	0.02 0.93	0.03 0.92	0.03 0.95	0.03 0.94		(43) (45)	0.02 1.00	0.03 1.00	0.03 1.00	0.03 1.00	0.03 1.00
(55)	0.34	0.51	0.58	0.50	0.49		(47)	0.74	0.65	0.64	0.66	0.66
(56) (57)	1.51 -2.23	1.16 -0.28	1.04 0.35	1.35 -1.40	1.25 -0.85		(49) (51)	0.03	0.05	0.06	— 0.06	0.06
	Exam-	Exam-	Exam-	Exam-	Exam-	. 45	(53) (54)	0.01 0.80	0.04 0.95	0.05 0.95	0.06 0.88	0.06 0.88
	ple28	ple29	ple30	ple31	ple32		(55)	0.37	0.52	0.53	0.53	0.53
(15)	-1.60	-1.56	-1.55	-2.00	-2.00	•	(56) (57)	0.93 0.62	1.56 -2.66	1.46 -2.07	1.00 0.30	1.69 -3.31
(16)	0.40	0.31	0.31	0.20	0.23	50						
(17) (18)	5.2 14.82	5.2 10.68	5.2 9.97	4.0 13.17	4.6 12.33	50		Exam- ple38	Exam- ple39	Exam- ple40	Exam- ple41	Exam- ple42
(19)	8.86	8.88	8.96	8.42	8.45		(15)	1.22	1.20	1.20	1 22	1.22
(20) (21)	1.50 0.47	1.65 0.63	1.68 0.81	2.02 0.79	1.98 1.15		(15) (16)	-1.33 0.23	-1.30 0.23	-1.30 0.23	-1.32 0.23	-1.32 0.23
(22)	0.03	0.05	0.06	0.02	0.04		(17)	5.4	4.9	4.8	4.5	4.5
(23) (24)	0.73 0.03	0.73 0.03	0.73 0.03	0.61 0.03	0.60 0.03	55	(18) (19)	4.49 5.80	14.80 7.71	12.59 7.83	0.65 6.54	0.40 6.33
(25)	0.46	0.47	0.45	0.51	0.53		(20)	2.51	2.26	2.30	1.66	1.63
(26) (27)	3.06 0.04	2.31 0.04	2.34 0.04	2.14 0.07	2.94 0.07		(21) (22)	0.70 0.04	0.52 0.19	0.45 0.20	0.72 0.71	0.74 0.74
(28)	0.37	0.37	0.37	0.51	0.60		(23)	0.67	0.70	0.71	0.76	0.76
(29) (30)	0.72 0.05	0.57 0.10	0.74 0.08	0.47 0.05	0.80 0.02	60	(24) (25)	0.03 0.55	0.02 0.58	0.02 0.60	0.03 0.56	0.03 0.56
(31)	0.43	0.47	0.41	0.34	0.37		(26)	2.06	1.88	1.90	1.59	1.52
(32)	0.42	0.46	0.41	0.36	0.39		(27)	0.07	0.05	0.05	0.04	0.04
(33) (34)	1.20 2.08	1.13 2.04	1.08 2.16	1.14 3.34	1.59 3.24		(28) (29)	0.74 0.31	0.45 0.94	0.43 1.03	0.37 0.44	0.37 0.27
(35)	3.79	4.22	3.96	2.46	3.54	65	(30)	0.33	0.13	0.28	0.28	0.14
(36)	0.20	0.19	0.20	0.32	0.27		(31)	0.63	0.81	0.92	0.80	0.83

	-continued						-continued						
(32) (33) (34)	0.66 1.31 2.22	0.82 1.12 1.88	0.93 1.26 1.84	0.87 1.31 1.77	0.86 1.28 1.65	5	(27) (28) (29)	0.04 0.38 0.00	0.04 0.38 -0.02	0.22 2.11 0.28	0.24 2.21 0.35	0.27 2.52 0.29	
(35) (36)	8.79 0.20	8.44 0.34	10.70 0.28	9.76 0.11	8.07 0.13		(30) (31)	1.45 0.66	1.67 0.75	0.13 0.89	0.12 1.05	0.12 0.99	
(37)	1.65	2.58	1.56	-17.82	2.90		(32)	0.71	0.80	0.92	1.11	1.02	
(38)	2.36	0.88	0.84	2.24	3.64		(33)	1.15	1.35	1.44	1.67	1.49	
(39) (40)	4.40	8.68 -6028.80	9.57 17.96	9.83 14.50	9.82		(34) (35)	2.32 9.80	2.39 10.26	2.53 6.96	2.43	2.47 6.93	
(41)	6.60 1.21	2.66	17.90	-5.68	161.18 0.99	10	(36)	0.12	0.12	0.28	7.76 0.26	0.93	
(42)	0.03	0.02	0.02	0.03	0.03		(37)	2.31	2.62	1.80	1.99	1.73	
(43)	0.03	0.02	0.02	0.03	0.03		(38)	-2459.34	-47.39	1.66	1.56	1.62	
(45) (47)	1.00 0.69	_	_	0.95 0.37	1.00 0.41		(39) (40)	16.97 2.48	-272.93 2.43	1.12 13.27	1.73 9.52	1.18 13.77	
(49)	-						(41)	1.35	1.30	1.62	1.68	1.60	
(51)	0.05	0.06	0.04	0.09	0.09	15	(42)	0.03	0.03	0.03	0.03	0.03	
(53)	0.05	0.25	0.26	0.04	0.04		(43)	0.03	0.03	0.02	0.02	0.02	
(54) (55)	0.89 0.49	0.92 0.55	0.92 0.57	0.93 0.59	0.93 0.63		(45) (47)	1.00 0.59	1.00 0.55	1.00 0.68	1.00 0.64	1.00 0.68	
(56)	1.08	1.24	1.26	1.21	1.20		(49)	_	_	_	_	_	
(57)	-0.04	-1.13	-1.22	-0.78	-0.81		(51)	0.14	0.17	0.03	0.03	0.03	
	Exam-	Exam-	Exam-	Exam-	Exam-	20	(53) (54)	0.17 0.94	0.22 0.93	0.03 0.70	0.02 0.66	0.02 0.65	
	ple43	ple44	ple45	ple46	ple47		(55)	0.55	0.57	0.41	0.43	0.42	
						-	(56)	1.32	1.32	0.74	0.72	0.69	
(15) (16)	-1.33 0.23	-1.33 0.23	-1.33 0.23	-1.33 0.20	-1.33 0.23		(57)	-0.99	-0.92	1.34	1.33	1.47	
(17)	5.0	5.0	5.0	5.0	5.0			Exam-	Exam-	Exam-	Exam-	Exam-	
(18)	4.40	4.37	5.34	4.33	6.79	25		ple53	ple54	ple55	ple56	ple57	
(19) (20)	10.74 2.54	8.43 2.49	8.41 2.31	8.41 2.45	8.39 2.47		(15)	-1.40	-1.40	-1.10	-1.56	-1.60	
(21)	0.89	1.61	2.27	2.43	0.82		(16)	0.17	0.17	0.23	0.20	0.20	
(22)	0.13	0.12	0.09	0.17	0.08		(17)	5.7	5.9	4.6	4.6	4.7	
(23)	0.73	0.73	0.73	0.73	0.73	30	(18)	1.55	1.10	16.84	-0.34	-4.26	
(24) (25)	0.03 0.52	0.03 0.51	0.03 0.48	0.03 0.48	0.03 0.53	30	(19) (20)	2.24 2.20	2.57 2.23	11.88 2.77	13.08 2.20	7.02 1.94	
(26)	1.78	1.75	1.65	1.50	1.80		(21)	0.80	0.79	0.31	1.01	0.98	
(27)	0.03	0.04	0.04	0.04	0.04		(22)	0.28	0.33	0.03	0.10	0.14	
(28) (29)	0.30 0.40	0.38 0.35	0.38 0.16	0.38 0.16	0.38 0.25		(23) (24)	0.48 0.03	0.51 0.03	0.53 0.03	0.62 0.02	0.61 0.03	
(30)	0.37	0.32	0.33	0.10	0.66	35	(25)	0.59	0.61	0.68	0.57	0.51	
(31)	0.59	0.55	0.47	0.44	0.63		(26)	2.01	2.11	2.50	2.22	2.04	
(32) (33)	0.60 1.03	0.57 1.10	0.50 1.10	0.47 1.02	0.65 1.05		(27) (28)	0.33 2.82	0.27 2.52	0.07 0.58	0.04 0.39	0.08 0.69	
(34)	2.00	2.05	2.18	2.23	2.06		(29)	0.20	0.29	0.38	0.59	0.85	
(35)	8.38	7.21	5.10	4.92	9.56		(30)	0.12	0.12	0.13	0.21	0.05	
(36)	0.14	0.15	0.20	0.20	0.12	40	(31)	0.90	0.99	0.80	0.51	0.38	
(37) (38)	1.74 2.05	1.72 2.30	1.96 4.74	1.96 4.49	1.81 3.37		(32) (33)	0.94 1.44	1.02 1.49	0.89 2.25	0.55 1.53	0.40 1.36	
(39)	22.06	9.97	9.04	8.98	10.58		(34)	2.64	2.47	2.94	2.85	3.07	
(40)	9.42	7.85	5.84	5.69	4.88		(35)	5.50	6.93	10.06	6.49	3.36	
(41) (42)	1.20 0.03	1.15 0.03	1.09 0.03	1.04 0.03	1.24 0.03		(36) (37)	0.35 1.60	0.28 1.73	0.19 12.47	0.15 9.82	0.23 4.78	
(43)	0.03	0.03	0.03	0.03	0.03	45	(38)	2.26	1.62	0.77	0.93	0.63	
(45)	1.00	1.00	1.00	1.00	1.00		(39)	13.33	1.18	8.21	10.05	2.92	
(47) (49)	0.67	0.66 —	0.65	0.62	0.65		(40) (41)	14.46 1.60	13.77 1.60	6.80 10.30	26.71 6.18	59.95 3.14	
(51)	0.05	0.05	0.06	0.06	0.08		(42)	0.03	0.03	0.03	0.10	0.03	
(53)	0.06	0.05	0.05	0.04	0.09		(43)	0.02	0.02	0.02	0.02	0.02	
(54)	0.95	0.94 0.52	0.94 0.50	0.94 0.49	0.94 0.54	50	(45)	1.00	1.00	1.00	1.00 0.77	0.45	
(55) (56)	0.53 1.48	1.32	1.32	1.32	1.32		(47) (49)	0.68	0.68	_		0.26	
(57)	-2.19	-1.24	-1.09	-1.05	-1.21		(51)	0.03	0.03	0.04	0.05	0.03	
	Exam-	Exam-	Exam-	Exam-	Exam-	-	(53) (54)	0.02 0.61	0.02 0.65	0.01 0.89	0.04 0.94	0.02 0.90	
	ple48	ple49	ple50	ple51	ple52	55	(55)	0.40	0.42	0.37	0.38	0.34	
	F	F	F	F	F	-	(56)	0.64	0.69	1.37	1.53	1.10	
(15)	-1.33	-1.33	-1.40	-1.33	-1.40		(57)	1.77	1.47	-1.70	-2.25	0.33	
(16) (17)	0.20 5.0	0.20 5.0	0.17 5.8	0.20 5.7	0.17 5.9			Exam-	Exam-	Exam-	Exam-	Exam-	
(18)	7.70	7.79	1.61	3.08	1.10			ple58	ple59	ple60	ple61	ple62	
(19)	8.50	8.49	3.05	2.84	2.57	60		*					
(20)	2.37	2.12	2.29	2.18	2.23		(15)	-1.33	-1.33	-1.33	-3.57	-3.56	
(21)	1.45	1.67	0.97	0.47	0.79		(16)	0.23	0.23	0.23	0.60	0.60 5.5	
(22) (23)	0.06 0.72	0.10 0.72	0.36 0.52	0.28 0.52	0.33 0.51		(17) (18)	5.5 8.68	5.6 -0.12	5.6 1.62	5.5 4.121	5.5 2.714	
(24)	0.03	0.03	0.03	0.03	0.03		(19)	7.46	7.70	8.43	0.12	0.14	
(25)	0.55	0.57	0.61	0.63	0.61	65	(20)	2.18	2.19	1.98	0.57	0.58	
(26)	1.65	1.65	2.10	2.31	2.11		(21)	0.82	0.75	0.79	0.80	0.79	

C22 0.14		-continued						-continued						
C25 0.03							_							
CS 0.59														
(26) 2.61 2.57 2.51 1.30 1.32 (21) 0.53 0.68 0.72 0.70 1.29 (27) 0.06 0.08 0.07 0.17 0.16 0.03 0.04 0.06 0.07 0.17 0.06 0.07 0.17 0.06 0.07 0.17 0.06 0.07 0.17 0.06 0.07 0.17 0.06 0.07 0.17 0.06 0.07 0.17 0.07 0.07 0.07 0.07 0.07 0.07							5							
127													1.29	
Color	(27)							(22)		0.04			0.03	
(31) 0.36 0.59 0.54 0.51 0.51 0.52 0.52 0.34 0.34 0.34 0.31 0.32 0.26 0.32 0.35 0.35 0.55 0.53 0.53 0.55 0.53 0.53										0.95			0.94	
Garding Gard														
132					0.21		10	(25)		0.34				
(33) 1.64 1.60 1.51 0.77 0.78 (28) 0.20 0.30 0.30 0.30 0.30 0.30 2.37 (24) (27) 2.66 2.77 1.13 1.13 (29) 0.21 0.21 0.22 0.23 0.23 0.35 0.30 0.30 0.30 0.30 (23) (35) 8.99 7.42 6.89 3.20 3.18 (20) 0.06 0.06 0.00 0.00 0.00 0.00 0.00 0.							10	(20)		0.04	0.04		0.06	
GAT C. C. C. C. C. C. C. C														
Georgia Geor														
(37) 3.32 3.09 3.04 -2.51 -2.20 15 (32) 0.52 0.52 0.43 0.48 0.38 (38) 0.78 0.74 1.04 -5.55 -5.20 (33) 0.80 0.84 0.09 0.43 0.038 (39) 6.02 2.79 4.50 0.01 1.032 0.31 0.80 0.84 0.09 0.43 1.07 1.01 1.05 1.05 1.05 1.05 1.05 1.05 1.05		8.99	7.42		3.20	3.18		(30)	0.06	0.09	0.04	0.02	0.15	
(38) 0.78 0.74 1.04 -5.56 -5.20 (33) 0.80 0.84 0.69 0.73 0.80 (39) (602 2.79 4.50 0.31 0.32 (34) 1.09 1.14 1.07 1.10 1.05 (40) 6.92 1.60 7.56 9.88 10.43 (35) 4.29 3.54 3.75 3.27 9.28 1.44 (1.17) 1.17 1.17 1.17 1.17 1.17 1.17 1.17								(31)					0.37	
109 6.02 2.79 4.50 0.31 0.32 (34) 1.09 1.14 1.07 1.10 1.05 (41) 1.79 1.77 1.70 -2.20 -2.16 (36) 0.19 0.20 0.23 0.24 0.21 0.31 (41) 0.20 0.03							15	(32)					0.38	
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(45) 0.70 0.69 0.75 0.75 0.75 (39) 3.03 7.87 23.82 8.76 5.83 (47) — — 0.44 0.44 0.44 55 (40) —9696.32 2.94 22.27 3.84 3.10 (49) — — — — — (41) —5.11 —0.58 —0.65 —0.76 —0.85 (51) 0.07 0.07 0.09 0.07 0.08 (42) 0.03														
(47) — — 0.44 0.44 0.44 55 (40) —9696.32 2.94 22.27 3.84 3.10 (49) — — — — — (41) —5.11 —0.58 —0.65 —0.76 —0.85 (51) 0.07 0.07 0.09 0.07 0.08 (42) 0.03														
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(51) 0.07 0.07 0.09 0.07 0.08 (42) 0.03 <th< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td>55</td><td></td><td></td><td></td><td></td><td></td><td></td></th<>							55							
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(54) 0.87 0.88 0.81 0.83 0.80 (45) 0.35 0.83 0.86 0.88 0.86 (55) 0.67 0.65 0.71 0.69 0.70 (47) 0.97 0.36 — 0.40 0.37 (56) 0.90 0.91 0.86 0.87 0.85 60 (49) —														
(55) 0.67 0.65 0.71 0.69 0.70 (47) 0.97 0.36 — 0.40 0.37 (56) 0.90 0.91 0.86 0.87 0.85 60 (49) — 0.19 — 0.03 0.03														
(56) 0.90 0.91 0.86 0.87 0.85 60 (49) — 0.98 0.94 0.92														
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$							60							
Example68 Example69 Example70 Example71 Example72 (53) 0.13 0.03 0.03 0.03 0.04 (15) -3.51 -3.51 -3.55 -3.53 -3.56 65 (57) 0.90 1.03 0.03 0.03 0.04 (15) 0.80 0.95 0.88 0.95 0.86 0.86 0.80 0.72 0.69 0.73 0.74 0.90 0.94 1.09 0.92 0.92 0.90 0.91 0.90 1.03 0.45 1.02 1.08														
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$							-							
(15) -3.51 -3.55 -3.53 -3.56 65 (57) 0.98 0.94 1.09 0.92 0.92 (15) -3.51 -3.51 -3.55 -3.53 -3.56 65 (57) 0.90 1.03 0.45 1.02 1.08		Exam-	Exam-	Exam-	Exam-	Exam-				0.88	0.95	0.86		
$ (15) \qquad -3.51 \qquad -3.55 \qquad -3.55 \qquad -3.53 \qquad -3.56 \qquad 65 (57) \qquad \qquad 0.90 \qquad 1.03 \qquad 0.45 \qquad 1.02 \qquad 1.08 $									0.80	0.72	0.69		0.74	
()							-							
(16) 0.60 0.59 0.62 0.60 0.81							65	(57)	0.90	1.03	0.45	1.02	1.08	
	(16)	0.60	0.59	0.62	0.60	0.81								

	-continued							-continued						
	Exam- ple78	Exam- ple79	Exam- ple80	Exam- ple81	Exam- ple82	-	(54 (55 (56	s) 0.78	0.65 0.69 0.71	0.85 0.56 0.87	0.86 0.60 0.88	0.81 0.74 0.85		
(15) (16)	-1.33 0.23	-2.20 0.38	-2.00 0.32	-2.00 0.32	-2.00 0.32	5	(57		1.52	1.17	1.10	1.06		
(17)	3.8	5.5	5.1	5.1	5.1			Exam-	Exam-	Exam-	Exam-	Exam-		
(18) (19)	2.970 0.92	7.326 6.01	5.550 1.47	6.867 0.89	6.856 0.89			ple88	ple89	ple90	ple91	ple92		
(20)	1.77	1.51	1.28	1.29	1.26		(15)	-4.18	-8.37	-2.04	-2.04	-4.09		
(21) (22)	0.98 0.29	0.73 0.01	$\frac{1.07}{0.11}$	1.14 0.10	1.30 0.06	10	(16) (17)	0.75 6.7	0.95 11.5	0.39 9.8	0.41 11.8	0.74 17.8		
(23)	0.87	0.74	0.90	0.87	0.87		(18)	7.905	17.163	10.582	9.821	16.263		
(24) (25)	0.030 0.46	0.030 0.46	0.030 0.39	0.030 0.40	0.030 0.38		(19) (20)	0.17 0.47	0.01 0.20	0.81 0.89	0.86 0.83	0.21 0.37		
(26)	1.08	3.74	1.22	1.24	1.24		(21)	0.65	0.44	0.60	0.59	1.95		
(27) (28)	0.08 0.55	0.05 0.53	0.05 0.44	0.08 0.72	0.08 0.72	15	(22) (23)	0.01 0.86	0.01 0.70	0.41 0.85	0.49 0.85	0.01 0.93		
(29)	-1.52	0.57	-1.18	-0.96	-0.96		(24)	0.030	0.030	0.032	0.032	0.030		
(30) (31)	0.64 0.71	0.08 0.44	0.54 0.54	0.54 0.62	0.55 0.55		(25) (26)	0.27 1.92	0.21 2.76	0.46 2.02	0.44 2.44	0.32 2.80		
(32)	0.85	0.46	0.57	0.65	0.59		(27)	0.14	0.41	0.10	0.10	0.06		
(33)	1.14	1.27	0.83	0.87	0.80	20	(28)	1.67	6.72	1.76	2.07	2.07		
(34) (35)	1.40 4.06	2.07 5.31	1.31 4.96	1.28 4.82	1.32 4.44		(29) (30)	-0.77 0.03	-0.29 0.06	-0.56 0.33	-0.54 0.30	-0.31 0.32		
(36)	0.21	0.16	0.23	0.23	0.23		(31)	0.41	0.42	0.79	0.71	0.43		
(37) (38)	-2.67 -2.12	3.89 1.86	-13.18 -1.60	-8.91 -2.00	-93.62 -2.00		(32) (33)	0.42 0.83	0.42 0.74	0.87 1.36	0.78 1.34	0. 49 1.11		
(39)	6.61	-1270.10	23.23	4.39	3.92	25	(34)	1.11	1.03	1.29	1.31	1.17		
(40) (41)	3.10 -0.80	30.48 1.39	4.24 -6.32	4.27 -5.14	3.86 -49.35	20	(35) (36)	6.98 0.08	-8.15 0.00	10.00 0.41	26.35 0.16	-13.67 0.00		
(42)	0.03	0.03	0.03	0.03	0.03		(37)	-8.54	-71.88	-0.53	-0.60	-2.01		
(43) (45)	0.03 0.85	0.02 1.00	0.03 0.83	0.03 0.82	0.03 0.80		(38) (39)	-4.16 0.36	-25.04 0.10	-2.50 3.60	-2.50 1.81	-10.00 1.07		
(47)	0.38	0.72	0.46	0.48	0.46	•	(40)	150.63	1016.39	4.03	4.75	2.77		
(49) (51)	— 0.19	0.05	0.13	— 0.11	 0.13	30	(41) (42)	-4.92 0.03	-53.92 0.03	-0.58 0.03	-0.69 0.03	-2.18 0.03		
(53)	0.05	0.02	0.06	0.07	0.07		(43)	0.03	0.03	0.03	0.03	0.03		
(54) (55)	0.88 0.74	0.93 0.51	0.93 0.70	0. 89 0.70	0.89 0.68		(45) (47)	0.82	0.80	0.58 0.88	0.62 0.88	0.64 0.87		
(56)	0.94	1.16	1.00	0.94	0.94		(49)	_	_	_	_	_		
(57)	1.04	-0.28	0.74	0.93	0.97	35	(51) (53)	0.08 0.02	0.06 0.02	0.10 0.02	0.10 0.02	0.13 0.01		
	Exam- ple83	Exam- ple84	Exam- ple85	Exam- ple86	Exam- ple87		(54) (55)	0.83 0.76	0.63 0.79	0.66 0.67	0.67 0.66	0.92 0.75		
				-		-	(56)	0.87	0.71	0.90	0.91	0.95		
(15) (16)	-1.32 0.33	-2.54 0.42	-2.58 0.40	-1.99 0.40	-4.18 0.74	40	(57)	1.04	1.02	0.98	0.98	1.09		
(17)	4.1	4.4	5.5	6.4	8.8	40		Exam-	Exam-	Exa		Exam-		
(18) (19)	9.402 3.16	21.517 0.58	3.391 1.03	2.859 1.19	8.190 0.11			ple93	ple94	ple9	95	ple96		
(20)	1.25	1.45	1.36	1.29	0.42		(15		-4.09	-2.		-2.00		
(21) (22)	1.19 0.39	0.74 0.09	$\frac{1.11}{0.01}$	0.80 0.01	0.59 0.03		(16 (17		0.69 17.8	0. 5.	32 2	0.32 5.2		
(23)	0.91	0.67	0.80	0.79	0.84	45	(18	8.840	14.080	1.	990	0.995		
(24) (25)	0.030 0.49	0.021 0.40	0.030 0.32	0.030 0.35	0.030 0.25		(19 (20		0.20 0.37		18 94	1.17 0.91		
(26)	1.07	2.82	2.13	1.96	2.00		(21	0.60	2.33	0.	85	0.73		
(27) (28)	0.02 0.18	0.32 2.12	0.12 1.23	0.12 1.35	0.17 2.52		(22 (23		0.45 0.92		50 91	0.35 0.91		
(29)	-2.12	1.14	-0.86	-1.51	-0.56	50	(24	0.032	0.030	0.	030	0.030		
(30) (31)	0.45 0.74	0.19 0.56	0.27 0.36	0.26 0.41	0.11 0.37		(25 (26		0.31 2.64		33 27	0.36 1.26		
(32)	0.85	0.71	0.37	0.43	0.38		(27		0.07		04	0.04		
(33) (34)	1.09 1.37	0.95 1.74	0.76 1.57	0.85 1.57	0.71 1.11		(28 (29		2.28 -0.29	0. -0.	44 70	0.44 -0.70		
(35)	5.65	23.80	4.49	4.50	17.87	55	(30	*	0.44		21	0.20		
(36)	0.22	0.06	0.34	0.42	0.05		(31		0.44		47	0.53		
(37) (38)	-4.40 -1.31	1.03 1.58	-3.39 -1.53	-1.68 -0.81	-8.39 -5.89		(32 (33	*	0.49 0.97		45 70	0.51 0.74		
(39)	55.20	0.30	0.79	0.77	0.26		(34	1.31	1.17	1.	18	1.16		
(40)	4.99	0.77	12.26	17.99	49.15	60	(35		-6.82		42	9.76		
(41) (42)	-1.49 0.03	1.19 0.02	-4.03 0.03	-1.67 0.03	-6.31 0.03	60	(36 (37		0.00 2.01		05 72	0.05 11.52		
(43)	0.03	0.02	0.03	0.03	0.03		(38	-2.51	-10.00	-3.	48	-3.50		
(45) (47)	0.90 0.42	 0.27	0.83	0.88	0.79		(39 (40		0.98 2.78	24. -105.		-4293.76 -105.84		
(47)	- 0.42 		_	_	_		(41	*	2.76		35	4.88		
(51)	0.14	0.21	0.09	0.09	0.08	65	(42	0.03	0.03	0.	03	0.03		
(53)	0.04	0.09	0.04	0.05	0.03		(43	0.03	0.03	0.	03	0.03		

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		-continue	.u		
(45)	0.61	0.64	0.81	0.83	_
(47)	0.88	_	0.31	0.29	
(49)	_	_	_	_	
(51)	0.10	0.12	0.06	0.05	
(53)	0.02	0.03	0.06	0.07	
(54)	0.67	0.91	0.94	0.94	
(55)	0.65	0.96	0.86	0.87	
(56)	0.91	0.94	0.99	0.99	
(57)	0.97	1.09	0.72	0.70	

Moreover, value of variable in each example are given below. Also, N_{G1} denotes number of lenses in the first lens unit, \mathbf{N}_{G2} denotes number of lenses in the second lens unit, \mathbf{f}_{G2} denotes a focal length of the second lens unit, \mathbf{f}_{G2i} denotes a focal length of the second image-side lens. Furthermore, \mathbf{f}_{L1} to F_{L19} denotes a focal length of each lens, and correspond to L1 to L19 shown in the cross-sectional view of the optical system. Also, with respect to the example which includes a 20 diffraction optical element, description for focal length of a lens, shown by DL in the cross-sectional view of the optical system, is omitted.

	Example8	Example9	Example10	Example11
D_{oi}	60.0	57.9	60.0	60.0
Y_{obj}	4.7	4.7	4.8	4.8
Y	4.92	4.92	4.92	4.92
L_{TL}	35.02	40.92	35.01	35.01
L_L	30.71	36.61	30.70	30.70
WD	25.00	17.00	25.00	25.00
BF	4.31	4.31	4.31	4.31
NA	0.15	0.21	0.15	0.15
β	-1.04	-1.05	-1.03	-1.03
f	9.34	9.35	9.35	10.22
ϕ_{G1o}	12.87	15.15	13.09	13.55
ϕ_s	4.84	5.70	4.73	4.77
D_{os}	38.52	35.88	38.53	38.18
D_{G1G2}	1.87	2.17	1.77	1.40
L_{GI}	12.37	17.71	12.51	12.20
L_{G2}	16.47	16.73	16.42	17.10
CRA _{obi} (MAX)	5.01	3.02	4.85	4.57
CRA _{obi} (MIN)	0.00	0.00	0.00	0.00
CRA _{ima}	20.40	23.21	20.47	20.41
D_{max}	5.72	5.24	5.70	4.65
D_{G1max}	1.23	2.49	0.99	1.10
vd _{max}	81.61	81.61	81.61	81.61
vd_{min}	30.30	30.30	30.30	31.32
N_{G1}	4.00	5.00	4.00	4.00
N_{G2}	5.00	5.00	6.00	6.00
f_{G1}	13.85	12.59	14.04	13.02
f_{G2}	53.90	19.64	34.90	39.91
f_{G1o}	24.63	23.26	23.74	21.53
f_{G2i}	-10.50	-8.84	-10.57	-10.74
f_{L1}	24.63	23.26	23.74	21.53
f_{L2}	27.02	-40.17	27.43	24.93
f_{L3}	12.38	18.64	10.99	13.31
f_{L4}	-6.99	9.77	-6.17	-6.78
f_{L5}	-15.63	-6.61	-16.62	-25.51
f_{L6}	51.27	-14.37	44.82	33.89
f_{L7}	20.88	73.73	11.13	20.46
f_{L8}	15.49	12.37	-12.69	8.23
f_{L9}	-10.50	22.47	11.28	-12.22
f_{L10}	_	-8.84	-10.57	-10.74

	Example12	Example13	Example14	Example15
D_{oi}	55.0	55.0	60.0	60.0
\mathbf{Y}_{obj} \mathbf{Y}	4.7	4.7	4.7	4.7
Y	4.92	4.92	4.92	4.92
L_{TL}	35.01	34.01	36.00	44.05
L_L	32.11	31.12	32.87	40.74
WD	20.00	21.00	24.00	15.97
BF	2.90	2.89	3.13	3.31

NA	0.18	0.13	0.14	0.21
β	-1.05	-1.05	-1.05	-1.05
f	7.99	8.59	9.49	8.84
ϕ_{G1o}	13.29	11.27	12.33	13.69
Φ_s	5.73	3.56	4.32	6.29
D_{os}	36.58	35.61	40.71	32.22
D_{G1G2}	1.64	1.24	1.41	4.13
L_{G1}	15.23	13.67	15.60	14.70
L_{G2}	15.23	16.21	15.86	21.90
$CRA_{obj}(MAX)$	5.01	5.02	4.45	5.03
CD A (MINI)	0.00	0.00	0.00	0.00

CRA_{obj} (MIN) 0.000.00 CRA_{img} 24.98 24.22 22.84 23.11 \mathbf{D}_{max} 3.01 3.60 3.25 4.13 \mathcal{D}_{G1max} 0.30 0.30 0.45 2.15 vd_{max} 81.61 81.61 81.61 81.61 vd_{min} 23.77 23.77 23.77 ${\rm N}_{G1}$ 6.00 6.00 ${\rm N}_{G2}$ 5.00 4.00 6.00 12.56 11.59 11.80 14.91 f_{G1} 65.83 67.00 -52.46 12.97 \mathbf{f}_{G2} 17.88 18.30 56.21 18.32 f_{G1o} -10.56 -15.34 -11.21 -9.44 18.32 17.88 18.30 56.21 37.07 -12.27-13.66 -11.91 16.27 15.26 13.04 24.83 16.48 13.67 14.27 10.19 -5.97

12.90 13.69 13.50 f_{L5} -6.44-5.79 -5.96-12.9325 -31.52 21.18 -27.43 14.43 114.04 49.38 15.97 -12.3322.67 20.52 22.94 19.76 f_{L10} 18.24 16.87 -15.34-17.31 \mathbf{f}_{L11} -9.44 -10.56-11.2130

	*L11	· · · · ·	10.00		11.21
30		Example16	Example17	Example18	Example19
	D_{oi}	60.0	60.0	60.0	70.0
	\mathbf{Y}_{obj}	4.7	4.7	4.7	4.9
	Y	4.92	4.92	4.92	4.92
25	L_{TL}	43.01	40.23	35.01	42.41
35	L_L	38.70	35.92	30.70	40.53
	$\overline{\mathrm{WD}}$	17.00	19.78	25.00	27.58
	BF	4.31	4.31	4.31	1.88
	NA	0.18	0.20	0.15	0.15
	β	-1.05	-1.05	-1.04	-1.00
40	f	10.48	10.21	8.63	9.02
40	ϕ_{G1o}	12.75	14.20	12.86	14.58
	Φ_s	4.52	5.67	5.89	5.59
	D_{os}	32.54	33.57	38.03	45.84
	D_{G1G2}	1.68	2.34	3.56	1.37
	L_{G1}	14.57	12.53	9.67	16.92
45	L_{G2}	22.44	21.05	17.47	22.24
10	$CRA_{obj}(MAX)$	4.97	5.01	5.00	4.01
	$CRA_{obj}(MIN)$	0.00	0.00	0.00	0.00
	CRA_{img}	18.67	18.43	22.74	21.84
	D_{max}	5.88	5.84	3.56	4.34
	D_{G1max}	0.10	1.38	0.10	2.78
50	vd_{max}	81.61	81.61	81.61	81.61
	vd_{min}	23.77	30.30	33.79	30.30
	N_{G1}	5.00	4.00	4.00	7.00
	N_{G2}	5.00	5.00	6.00	7.00
	f_{G1}	12.37	13.75	17.15	14.57
	f_{G2}	13.91	16.65	35.67	-25.41
55	f_{G1o}	54.82	24.83	21.39	68.99
	f_{G2i}	-10.13	-12.05	-12.01	-13.57
	f_{L1}	54.82	24.83	21.39	24.92
	f_{L2}	27.79	27.96	22.33	34.57
	f_{L3}	21.01	11.33	15.76	15.04
	f_{L4}	8.55	-6.47	-7.77	-10.67
60	f_{L5}	-4.58	-17.53	-11.67	-9.30
	f_{L6}	-8.88	38.34	9.71	18.19
	f_{L7}	16.30	14.48	12.02	25.65
	f_{L8}	14.63	48.32	28.79	145.05

24.09

-10.13

 f_{L9}

 f_{L10} f_{L11} -12.05

-14.54

-12.01

13.70

-19.71

-13.57

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		-continued						-continued		
	Example20	Example21	Example22	Example23	-	$\overline{\mathrm{f}_{L3}}$	25.01	23.90	32.04	19.95
	Example20	Example21	Example22	Example23		f_{L4}	22.31	23.14	20.04	22.33
D_{oi}	50.5	90.0	74.0	75.0		f_{L5}	19.81	18.73	26.48	-18.00
Y_{obj}^{oi}	3.7	3.7	3.7	3.7	5	f_{L6}	-10.74	-11.95	-20.40	-9.19
Y	4.92	4.92	4.92	4.92		f_{L7}	-10.27	-11.22	-9.37	15.85
L_{TL}	36.73	60.00	44.01	45.00		f_{L8}	13.10	14.37	15.36	21.65
L_L	34.85	58.09	42.57	42.76		f_{L9}	22.47	24.09	22.49	-14.46
WD	13.80	30.00	30.00	30.00		f_{L10}	-26.66	-50.83	-12.32	9.47
BF	1.88	1.91	1.44	2.25	10	f_{L11}	12.62	12.52	9.13	-9.78
NA e	0.23	0.23	0.23	0.23	10	-L12	-10.03 -20.20	-10.05	-9.73	-18.62
β f	-1.33 5.76	-1.33 11.95	-1.33 9.09	-1.33 8.95		f_{L13}	-20.20	-13.47	-21.78	_
φ _{G10}	11.62	18.29	18.37	18.43			Example28	Example29	Example30	Example31
ϕ_s	5.58	8.60	9.67	9.49			Example26	Example29	Examples	Examples
D_{os}	27.52	46.38	45.86	46.52		\mathbf{D}_{oi}	67.0	67.0	67.0	60.0
D_{G1G2}	2.33	2.52	0.72	0.82	15	Y_{obj}	3.1	3.2	3.2	2.5
L_{G1}	12.55	14.93	14.92	15.58		Y	4.92	4.92	4.92	4.92
L_{G2}	19.96	40.64	26.93	26.36		L_{TL}	50.99	50.97	50.83	39.12
$CRA_{obj}(MAX)$	5.03	3.42	3.77	3.66		\mathbb{L}_L	49.18	49.16	49.02	36.64
$CRA_{obj}(MIN)$	0.00	0.00	0.00	0.00		WD	16.02	16.04	16.18	20.90
CRA _{img}	24.38	16.41	14.28	16.19		BF	1.81	1.81	1.81	2.48
D_{max}	5.67	16.81	5.38	6.22	20	NA	0.40	0.31	0.31	0.20
D_{G1max}	0.74	0.10	0.71	0.10		β	-1.60	-1.56	-1.55	-2.00
vd _{max}	81.61 23.77	81.61 23.77	81.61 23.77	81.61 30.30		f h	5.39 18.74	5.41 14.61	5.52 14.78	6.48 10.53
$\operatorname{vd}_{min} \operatorname{N}_{G1}$	5.00	6.00	6.00	7.00		Φ_{G1o} Φ_s	13.40	10.17	10.06	6.66
N_{G2}	7.00	7.00	7.00	7.00		D_{os}	30.52	31.48	30.31	30.56
f_{G1}	11.79	15.93	14.56	14.90		D_{G1G2}	0.73	1.01	0.78	0.35
f_{G2}	20.63	-148.45	-15.87	-17.93	25	L_{G1}	14.68	15.41	14.04	9.16
f_{G1o}	12.16	27.51	34.51	-433.62		L_{G2}	33.77	32.74	34.20	27.13
f_{G2i}	-11.27	-61.84	-112.48	-44.15		$CRA_{obj}(MAX)$	5.01	4.86	5.01	4.25
f_{L1}	12.16	27.51	34.51	-433.62		CRA _{obi} (MIN)	0.00	0.00	0.00	0.00
f_{L2}	-9.59	-47.88	-54.36	30.29		CRA_{img}	24.98	24.99	24.99	13.24
f_{L3}	8.46	23.28	28.64	-40.89	20	D_{max}	6.33	6.37	8.18	5.26
f_{L4}	9.45	24.16	25.30	25.88	30	- GImax	0.44	0.54	0.64	0.10
f_{L5}	-5.84 7.46	21.16	16.94	25.01 15.79		Vd _{max}	81.61 23.77	81.61	81.61	81.61 23.77
f_{L6}	-7.46 11.13	-8.36 -8.13	-11.17 -8.34	-10.39		$\mathrm{vd}_{min} \ \mathrm{N}_{G1}$	5.00	23.77 5.00	23.77 5.00	5.00
f_{L7} f_{L8}	35.93	14.39	16.41	-8.30		N_{G2}	7.00	7.00	6.00	7.00
f_{L9}	37.12	27.87	14.16	17.85		f_{G1}	12.63	12.85	12.89	11.74
f_{L10}	16.62	46.31	-11.47	13.12	35		-19.08	-18.81	-27.03	-14.14
f_{L11}	-19.11	23.89	9.84	-11.60	-	f_{G1o}	36.71	36.28	33.71	46.69
f_{L12}	-11.27	-13.98	-9.96	9.84		f_{G2i}	-12.14	-11.41	-10.64	1004.70
f_{L13}	_	-61.84	-112.48	-12.08		f_{L1}	36.71	36.28	33.71	46.69
f_{L14}	_	_	_	-44.15		f_{L2}	40.13	44.47	57.34	46.74
					•	f_{L3}	21.15	19.96	18.06	25.46
	Example24	Example25	Example26	Example27	40	f_{L4}	24.31	23.47	20.89	13.56
	70.0	67.0	67.0	67.0	•	f_{L5}	-22.06	-21.47	-17.23	-12.34
\mathbf{D}_{oi} \mathbf{Y}_{obj}	70.0 2.2	67.0 1.9	67.0 1.9	67.0 1.9		f_{L6}	-9.37 13.36	-9.35 13.37	-9.76 13.67	-8.13 11.38
Y obj	4.92	4.92	4.92	4.92		$egin{array}{l} \mathbf{f}_{L7} \ \mathbf{f}_{L8} \end{array}$	34.78	34.82	33.26	38.36
\mathcal{L}_{TL}	54.21	55.51	51.22	51.22		f_{L9}	-104.76	-93.84	16.88	270.72
L_L	51.58	52.41	49.41	49.09		f_{L10}	15.68	14.70	-15.01	13.62
WD	15.80	11.50	15.80	15.80	45	f_{L11}	-14.06	-13.63	-10.64	-6.90
BF	2.63	3.10	1.81	2.13		f_{L12}	-12.14	-11.41	_	1004.70
NA	0.38	0.43	0.40	0.40						
β	-2.20	-2.55	-2.55	-2.55			Example32	Example33	Example34	Example35
f	5.02	4.06	4.53	4.30						
Φ _{G10}	16.68	14.25	16.84	16.89	50	D_{oi}	70.0	74.0	62.7	63.0
Φ^{2}	11.49	11.77	12.92	12.50	50	- 001	2.5	3.7	3.7	3.7
D_{os}	32.14	27.52	31.44	30.95		Y	4.92	4.92	4.92	4.92
D_{G1G2}	0.96	1.10	0.36	0.52		L_{TL}	44.98	44.01	46.52	46.88
L _{G1}	15.55 35.06	15.33 35.97	15.63 33.42	15.10 33.47		$egin{array}{c} egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}$	42.01 25.04	38.79 30.00	45.18 16.17	45.36 16.07
L_{G2} CRA_{obj} (MAX)	3.01	3.02	3.01	3.02		BF	2.96	5.22	1.34	1.52
$CRA_{obj}(MIN)$	0.00	0.00	0.00	0.00	55	NA	0.23	0.23	0.23	0.23
CRA _{obj} (MIN)	19.17	20.97	14.87	16.57	23	β	-2.00	-1.33	-1.33	-1.33
D_{max}	8.48	12.20	11.08	11.58		f	10.51	10.24	6.71	6.94
D_{max} D_{G1max}	0.10	0.71	0.70	0.43		φ _{G10}	14.46	19.03	13.17	13.35
vd _{max}	81.61	81.61	81.61	81.61		ΨG10 Φ _s	8.46	9.19	5.88	5.84
vd_{max} vd_{min}	23.77	23.77	23.77	23.77		D_{os}	36.91	47.62	33.61	33.98
N_{G1}	6.00	6.00	6.00	5.00	60	D_{G1G2}	0.16	0.54	1.53	2.17
N_{G2}	7.00	7.00	7.00	7.00	5.0	L _{G1}	11.38	16.67	16.47	16.61
f_{G1}	14.02	12.99	12.42	12.17		L_{G2}	30.47	21.58	27.18	26.59
f_{G2}	919.29	85.22	-9.39	-9.08		CRA _{obj} (MAX)	3.30	3.22	3.54	3.17
f_{G1o}	19.51	15.80	25.17	28.64		$CRA_{obj}(MIN)$	0.00	0.00	0.00	0.00
f_{G2i}	-20.20	-13.47	-21.78	-18.62		CRA	12.08	16.48	25.00	25.00
f_{L1}	19.51	15.80	25.17	28.64	65	D_{max}	9.72	5.87	5.23	5.15
f_{L2}	-30.65	-25.58	-77.15	43.10		DG1 _{max}	0.30	0.10	0.96	0.92
E-Z		20.00		.5.10		max	0.00			

		-continued						continued		
vd_{max}	81.61	81.61	81.61	81.61		φ _{G10}	14.42	11.43	10.95	13.19
vd_{min}	23.77	23.77	23.77	23.77		Φ_s	6.70	7.60	7.60	5.86
N_{G1}	5.00	6.00	6.00	6.00	5	D_{os}	38.48	30.69	30.14	33.82
N_{G2}	6.00	6.00	7.00	6.00		D_{G1G2}	1.85	2.15	1.09	2.17
f_{G1} f_{G2}	12.00 -16.50	15.66 -40.91	11.76 416.18	11.71 -1160.10		L_{G1} L_{G2}	20.97 22.70	17.35 21.74	18.23 21.93	16.89 28.56
f_{G1o}	43.72	41.25	13.37	13.51		$CRA_{obj}(MAX)$	3.01	3.44	3.94	3.44
f_{G2i}	100.51	-10.63	-22.33	-16.72		$CRA_{obi}(MIN)$	0.00	0.00	0.00	0.00
f_{L1}	43.72	41.25	13.37	13.51		CRA	10.83	31.50	31.28	25.01
f_{L2}	32.19	-52.01	-11.61	-11.84	10	D_{max}	3.03	5.48	5.63	5.19
f_{L3}	28.02	20.63	16.56	16.66		D_{G1max}	1.32	5.37	5.63	0.79
$egin{array}{l} \mathbf{f}_{L4} \ \mathbf{f}_{L5} \end{array}$	14.03 -11.74	27.75 18.33	16.39 11.85	16.73 12.07		vd _{max} vd _{min}	81.61 34.71	81.61 23.78	81.61 23.78	81.61 23.77
f _{L6}	-7.83	-9.85	-6.77	-7.04		N_{G1}	6.00	6.00	6.00	6.00
f_{L7}	14.26	-10.09	-8.39	-8.08		N_{G2}	5.00	7.00	8.00	6.00
f_{L8}	41.26	20.06	14.89	14.88	15	f_{G1}	12.35	16.76	15.57	11.28
f_{L9}	14.80	12.65	25.19	17.50		f_{G2}	-163.05	16.34	50.69	-144.12
f_{L10}	-9.79	-9.90	46.83	19.53		f_{G1o}	17.51	-95.25	15.42	13.55
f_{L11}	100.51	8.86 -10.63	19.06 -11.47	-15.02		f_{G2i}	-14.09	-8.02 -95.25	-8.02 15.42	-17.68
$f_{L12} \\ f_{L13}$		-10.03	-22.33	-16.72 —		$egin{aligned} \mathbf{f}_{L1} \ \mathbf{f}_{L2} \end{aligned}$	17.51 -15.40	15.53	-95.25	13.55 -12.00
¹ L13			22.55		20	f_{L3}	18.06	-10.25	-10.36	16.82
	Example36	Example37	Example38	Example39	20	f_{L4}^{L3}	30.22	9.23	9.23	17.00
						f_{L5}	14.86	10.02	10.82	12.05
D_{oi}	64.1	65.0	74.6	65.2		f_{L6}	-12.27	-8.45	-10.39	-7.41
Y_{obj}	3.7	3.7	3.7	3.8		f_{L7}	13.83	-19.97	-13.77	-7.57
Y	4.92 47.90	4.92 48.69	4.92 53.56	4.92 48.01		f_{L8}	-7.40 -763.86	15.92 31.04	18.92 46.98	14.99 16.82
$egin{array}{c} egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}$	44.23	47.50	49.95	45.78	25	f_{L9} f_{L10}	13.22	10.32	60.83	23.13
WD	16.16	16.30	21.00	17.18		f_{L11}	-14.09	-12.97	9.60	-16.89
BF	3.68	1.19	3.62	2.23		f_{L12}	_	1200.49	-13.50	-17.68
NA	0.23	0.23	0.23	0.23		f_{L13}	_	-8.02	247.70	_
β	-1.33	-1.33	-1.33	-1.30		f_{L14}	_	_	-8.02	_
f	8.73	8.25	9.31	11.64	30		T 1.44	T 1.45	E 1.46	E 1.47
Ф _{G10}	13.51 5.94	13.57 5.87	15.22 6.90	14.22 6.93	30		Example44	Example45	Example46	Example47
Φ_s D_{os}	34.66	34.69	40.82	37.85		D_{oi}	65.0	65.0	65.0	65.0
D_{G1G2}	2.23	2.15	2.29	0.87		Y_{obj}^{oi}	3.7	3.7	3.7	3.7
L_{G1}	17.20	17.11	18.37	20.17		Y	4.92	4.92	4.92	4.92
L_{G2}	24.80	28.25	29.28	24.74		L_{TL}	49.15	49.18	49.18	49.20
CRA _{obj} (MAX)	3.04	3.04	3.19	3.59	35	L_L	47.27	47.29	47.30	47.32
$CRA_{obj}(MIN)$ CRA_{img}	0.00 20.87	0.00 18.64	0.00 15.64	0.00 10.46		WD BF	15.85 1.88	15.83 1.88	15.82 1.88	15.80 1.88
D_{max}	5.08	5.21	4.86	3.62		NA	0.23	0.23	0.20	0.23
DG1 _{max}	0.92	0.79	0.30	1.32		β	-1.33	-1.33	-1.33	-1.33
vd _{max}	81.61	81.61	81.61	81.61		f	7.87	7.55	7.55	8.00
vd_{min}	23.77	23.77	23.77	32.36	40	ϕ_{G1o}	12.90	12.18	11.08	13.30
N_{G1}	6.00	6.00	6.00	6.00		Φ_s	5.98	6.43	5.65	6.02
$ m N_{G2} m f_{G1}$	5.00 11.61	7.00 11.76	6.00 12.68	5.00 11.29		D_{os}	33.07	31.52	30.90	34.46
f_{G2}	238.11	152.21	-40.68	-27.34		D_{G1G2}	1.91 16.14	2.11	1.98 13.84	4.00 16.69
f_{G1o}	13.83	13.48	15.35	30.09		L_{G1} L_{G2}	29.23	14.43 30.75	31.48	26.63
f_{G2i}	-8.72	1846.69	-9.62	-13.42		OD A (MARK)	3.85	4.92	5.03	3.03
f_{L1}	13.83	13.48	15.35	30.09	45	CRA_{obj} (MIN)	0.00	0.00	0.00	0.00
f_{L2}	-11.77	-11.53	-13.63	-26.10		CRA _{img}	25.01	25.01	25.01	24.94
f_{L3}	17.05	15.57	17.12	16.79		D_{max}	9.60	14.60	15.60	4.94
f_{L4}	16.34 12.87	17.36 11.81	17.69 16.75	23.91 21.98		D_{G1max}	0.72	0.57	0.95	0.51
$egin{aligned} \mathbf{f_{L5}} \\ \mathbf{f_{L6}} \end{aligned}$	-7.52	-6.86	-8.50	-25.35		vd_{max}	81.61	81.61	81.61	81.61
f_{L7}	-7.59	-8.30	-7.69	24.96	50	vd_{min}	23.77	23.77	23.77	23.77
f_{L8}	15.13	14.58	18.30	-6.92		N_{G1}	6.00	6.00	6.00	6.00
f_{L9}	16.05	19.96	36.70	183.01		N_{G2}	6.00	6.00	6.00	6.00
f_{L10}	21.08	85.87	26.35	13.30		f_{G1}	11.80	13.57	14.24	11.71
f_{L11}	-8.72	19.60	19.77	-13.42		f_{G2}	91.51	24.06	18.81	-451.46
f_{L12}	_	-8.10 1846.69	-9.62 —	_		f _{Glo}	13.54 -18.99	14.77 -12.64	14.79 -12.42	14.48 -15.93
f_{L13}		1840.09			33	f_{G2i} f_{L1}	13.54	14.77	14.79	14.48
	Example40	Example41	Example42	Example43		\mathbf{f}_{L2}	-13.28	-17.01	-17.43	-12.43
						\mathbf{f}_{L3}	16.99	23.54	22.87	16.62
D_{oi}	64.2	54.5	54.1	65.0		f_{L4}	18.92	19.07	19.69	18.07
\mathbf{Y}_{obj}	3.8	3.6	3.6	3.7		f_{L5}	12.23	14.42	14.57	15.43
Y	4.92	4.75	4.75	4.92	60		-6.91	-7.15	-6.88	-8.97
\mathcal{L}_{TL}	47.64	43.00	43.00	49.10		f_{L7}	-8.30	-11.29	-12.11	-7.82
L_L	45.52	41.24	41.24	47.62		f_{L8}	25.05	44.46	44.73	14.98
WD	16.60	11.49	11.12	15.90		f_{L9}	13.37	12.12	12.07	15.98
BF	2.12	1.76	1.76	1.48		f_{L10}	21.39	21.40	21.25	25.19
NA 0	0.23	0.23	0.23	0.23	65	f_{L11}	-17.93	-31.10	-31.18	-19.41
β f	-1.30	-1.32 5.34	-1.32 5.31	-1.33	65	f_{L12}	-18.99	-12.64	-12.42	-15.93
1	11.19	5.34	5.31	7.78						

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	Example48	Example49	Example50	Example51		f_{L5}	22.74	21.08	22.74	-9.43
D.	65.0	65.0	00.4	96.6		f_{L6}	-12.18	-11.88	-12.18	-10.58
\mathbf{D}_{oi}	65.0 3.7	65.0 3.7	88.4 3.5	86.6 3.7	5	f_{L7}	-10.12 38.42	-9.91 37.46	-10.12 38.42	27.16 10.93
\mathbf{Y}_{obj} \mathbf{Y}	4.92	4.92	4.92	4.92		f_{L8} f_{L9}	10.60	10.57	10.60	-10.48
\mathcal{L}_{TL}	49.00	48.98	56.76	55.68		f_{L10}	-11.69	-12.74	-11.69	9.62
L_L^{TL}	47.12	47.09	46.38	44.80		f_{L11}	11.21	12.21	11.21	459.63
WD	16.00	16.02	31.64	30.90		f_{L12}	-11.85	-13.78	-11.85	-13.99
BF	1.88	1.89	10.38	10.88	10		D 156	D 1.57	D 150	E 1.50
NA β	0.20 -1.33	0.20 -1.33	0.17 -1.40	0.20 -1.33	10		Example56	Example57	Example58	Example59
f	7.74	7.45	14.81	14.41		D_{oi}	69.8	70.0	84.0	85.0
ϕ_{G1o}	12.20	12.20	14.75	17.05		Y_{obj}	3.1	3.1	3.7	3.7
Φ_s	5.88	6.58	7.84	9.19		Y	4.92	4.92	4.92	4.92
D_{os}	35.51	36.89	53.84	54.48		L_{TL}	45.08	46.29	54.27	55.20
L_{G1}	8.50 15.31	11.00 15.45	1.06 21.29	1.10 22.38	15	\mathcal{L}_L WD	43.19 24.76	42.91 23.71	50.28 29.74	51.33 29.80
L_{G2}	23.30	20.64	24.03	21.32		BF	1.89	3.38	3.99	3.87
$CRA_{obj}(MAX)$	3.02	3.01	3.01	3.01		NA	0.20	0.20	0.23	0.23
CRA _{obi} (MIN)	0.00	0.00	0.00	0.00		β	-1.56	-1.60	-1.33	-1.33
CRA_{img}	24.98	24.96	10.94	11.81		f	7.72	8.33	9.33	10.42
D_{max}	8.50	11.00	7.57	4.33	20	Φ _{G10}	13.97	12.57	19.32	18.99
D _{G1max}	0.36 81.61	0.67	2.79	2.58 81.61		Φ_s	7.44 40.08	8.16 35.89	9.84 49.92	9.81 49.35
vd _{max} vd _{min}	23.77	81.61 23.77	81.61 23.77	23.77		\mathcal{D}_{os} \mathcal{D}_{G1G2}	1.56	0.43	2.56	1.59
N_{G1}	6.00	6.00	6.00	6.00		L_{G1}	14.06	11.71	18.40	18.52
N_{G2}	6.00	6.00	6.00	6.00		L_{G2}	27.56	30.78	29.32	31.22
f_{G1}	13.24	15.01	16.44	17.09	25	$CRA_{obj}(MAX)$	3.14	4.34	2.81	3.15
f_{G2}	-4737.68	153.91	-32.88	-46.90	23	CRA _{obj} (MIN)	0.00	0.00	0.00	0.00
f _{Glo}	17.84 -18.73	19.51 -18.39	26.68 -11.47	28.65 -11.38		CRA _{img}	20.33 7.48	18.96 8.00	18.64 8.10	17.68 7.34
f_{G2i} f_{L1}	17.84	19.51	26.68	28.65		D_{max} D_{G1max}	0.75	1.16	1.33	0.30
\mathbf{f}_{L2}	-13.04	-12.13	-18.02	-18.66		vd	81.61	81.61	81.61	81.61
f_{L3}	18.46	18.52	20.01	20.10		vd	30.30	23.77	23.77	23.77
f_{L4}	17.54	16.97	22.79	22.92	30	N_{G1}	7.00	7.00	6.00	6.00
f_{L5}	30.17	63.84	22.94	22.12		N_{G2}	7.00	6.00	8.00	8.00
f_{L6}	-15.22	-23.74	-12.18 -10.31	-11.48 -10.82		f_{G1}	12.26 -10.13	12.68 -16.59	17.28 -44.18	15.88 -27.06
£										-27.00
f_{L7}	-10.47 20.62	-13.12 25.33				f_{G2}				
f_{L8}	20.62	25.33	37.48	33.16		f_{G1o}	75.80	39.79	30.99	31.29
$f_{L8} \\ f_{L9} \\ f_{L10}$	20.62 15.14 31.20	25.33 15.13 29.27			35	f_{G1o} f_{G2i}				
f_{L8} f_{L9}	20.62 15.14 31.20 -16.22	25.33 15.13 29.27 -15.24	37.48 10.62 -11.87 11.28	33.16 10.85 -10.97 10.23	35	$\begin{array}{c} \mathbf{f}_{G1o} \\ \mathbf{f}_{G2i} \\ \mathbf{f}_{L1} \\ \mathbf{f}_{L2} \end{array}$	75.80 -26.89 21.02 62.82	39.79 -92.10 39.79 20.87	30.99 -10.89 30.99 -33.07	31.29 -9.44 31.29 -30.71
$f_{L8} \\ f_{L9} \\ f_{L10}$	20.62 15.14 31.20	25.33 15.13 29.27	37.48 10.62 -11.87	33.16 10.85 -10.97	35	f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3}	75.80 -26.89 21.02 62.82 15.66	39.79 -92.10 39.79 20.87 13.01	30.99 -10.89 30.99 -33.07 20.09	31.29 -9.44 31.29 -30.71 19.65
f_{L8} f_{L9} f_{L10} f_{L11}	20.62 15.14 31.20 -16.22 -18.73	25.33 15.13 29.27 -15.24 -18.39	37.48 10.62 -11.87 11.28 -11.47	33.16 10.85 -10.97 10.23 -11.38	35	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51	39.79 -92.10 39.79 20.87 13.01 -13.25	30.99 -10.89 30.99 -33.07 20.09 32.66	31.29 -9.44 31.29 -30.71 19.65 29.48
f_{L8} f_{L9} f_{L10} f_{L11}	20.62 15.14 31.20 -16.22	25.33 15.13 29.27 -15.24	37.48 10.62 -11.87 11.28	33.16 10.85 -10.97 10.23	35	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \end{array}$	75.80 -26.89 21.02 62.82 15.66	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05	30.99 -10.89 30.99 -33.07 20.09	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15
f _{L8} f _{L9} f _{L10} f _{L11} f _{L12}	20.62 15.14 31.20 -16.22 -18.73	25.33 15.13 29.27 -15.24 -18.39	37.48 10.62 -11.87 11.28 -11.47	33.16 10.85 -10.97 10.23 -11.38		f_{G1o} f_{C2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L4} f_{L5} f_{L6}	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43	39.79 -92.10 39.79 20.87 13.01 -13.25	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45	31.29 -9.44 31.29 -30.71 19.65 29.48
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline D_{oi} \\ Y_{obj} \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5	25.33 15.13 29.27 -15.24 -18.39 Example53	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5	33.16 10.85 -10.97 10.23 -11.38 Example55	35	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L6} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55
f _{L8} f _{L9} f _{L10} f _{L11} f _{L12} D _{oi} Y _{obj}	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92	25.33 15.13 29.27 -15.24 -18.39 Example53	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92		$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95		$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63
$egin{array}{ll} f_{L8} & f_{L9} & f_{L10} & f_{L110} & f_{L111} & f_{L12} & & & \\ \hline D_{oi} & Y_{obj} & Y & & & \\ Y_{L}T_{L} & & & & \\ L_{L} & & & & \\ L_{L} & & & & \\ \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11		$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95	40	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23		$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example 62	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{LL} \\ WD \\ BF \\ NA \\ \beta \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10	40	f _{G1o} f _{G2i} f _{L1} f _{L1} f _{L3} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L7} f _{L8} f _{L9} f _{L10} f _{L10}	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36	40	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \hline D_{oi} \\ Y_{obj} \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -10.89 Example62	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36	40	f _{G1o} f _{G2i} f _{G2i} f _{L1} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L11}	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{LL} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \Phi_s \\ D_{os} \\ \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36	40	f _{G1o} f _{G2i} f _{G2i} f _{L1} f _{L1} f _{L2} f _{L3} f _{L3} f _{L6} f _{L7} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L10} f _{L11}	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -10.89 Example62	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{TL} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{GIG2} \\ \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13	40	f _{G1o} f _{G2i} f _{G2i} f _{L1} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L10} f _{L111} D _{oi} Y _{obj} Y L _{TL} L _L WDD	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \Phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25	40	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ \\ f_{L11} \\ \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73	40	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L110} \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ V \\ L_{IL} \\ L_{IL} \\ WD \\ BF \\ NA \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01	40	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ UD \\ BF \\ NA \\ \beta \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01	40	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ \end{array}$ $\begin{array}{c} D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MIN) \\ CRA_{bng} \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{GIG2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MIN) \\ CRA_{ing} \\ D_{max} \\ D_{GImax} \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01	40	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MIN) \\ CRA_{ing} \\ D_{max} \\ D_{GImax} \\ vd_{max} \end{array}$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L110} \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y_{ob$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 23.77	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L0} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ V \\ L_{IL} \\ UD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} $	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 23.77 6.00	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{L} \\ WDD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \Phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 2.37 6.00 6.00	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00 7.00	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{LL} \\ U_{LL} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \Phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ CRA_{obj} (MAX) \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78 3.28	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70 4.92	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17 4.96	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46 4.69
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 2.377 6.00 6.00 15.95	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00 7.00 14.96	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78 3.28 0.00	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70 4.92 0.00	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17 4.96 0.00	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46 4.69 0.00
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 6.00 6.00 16.59 -32.02	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 23.77 6.00 6.00 6.00 6.00 15.95 -37.38	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00 7.00 14.96 -35.27	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78 3.28 0.00 16.87	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70 4.92 0.00 11.98	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17 4.96 0.00 12.41	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46 4.69 0.00 14.58
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 23.77 6.00 6.00 15.95 -37.38 25.52	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00 7.00 14.96 -35.27 154.11	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{IL} \\ UMD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{of} \\ Q_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78 3.28 0.00 16.87 8.57	39.79 -92.10 39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70 4.92 0.00 11.98 9.46	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17 4.96 0.00 12.41 9.47	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46 4.69 0.00 14.58 13.98
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47 -11.85	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 23.77 6.00 6.00 15.95 -37.38 25.52 -13.78	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47 -11.85	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00 7.00 14.96 -35.27 154.11 -13.99	40 45 50	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ V \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{G1} \\ G2 \\ CRA_{obj} \\ (MIN) \\ CRA_{obj} \\ (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78 3.28 0.00 16.87 8.57 0.30	39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70 4.92 0.00 11.98 9.46 0.08	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17 4.96 0.00 12.41 9.47 0.07	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46 4.69 0.00 14.58 13.98 0.05
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 23.77 6.00 6.00 15.95 -37.38 25.52	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00 7.00 14.96 -35.27 154.11	40 45 50 60	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{D9} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78 3.28 0.00 16.87 8.57	39.79 -92.10 39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70 4.92 0.00 11.98 9.46	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17 4.96 0.00 12.41 9.47	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46 4.69 0.00 14.58 13.98
$\begin{array}{c} f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	20.62 15.14 31.20 -16.22 -18.73 Example52 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47 -11.85 26.47	25.33 15.13 29.27 -15.24 -18.39 Example53 87.0 3.5 4.92 55.96 42.08 31.04 13.88 0.17 -1.40 15.97 14.13 8.06 51.40 0.95 19.48 21.65 3.42 0.00 9.64 6.45 2.30 81.61 23.77 6.00 6.00 15.95 -37.38 25.52 -13.78 25.52	37.48 10.62 -11.87 11.28 -11.47 Example54 90.0 3.5 4.92 58.18 45.80 31.82 12.38 0.17 -1.40 15.30 14.80 8.07 54.96 1.00 22.24 22.57 3.01 0.00 10.57 6.35 2.65 81.61 23.77 6.00 6.00 16.59 -32.02 26.47 -11.85 26.47	33.16 10.85 -10.97 10.23 -11.38 Example55 78.8 4.5 4.92 44.95 42.11 33.80 2.85 0.23 -1.10 12.36 22.36 9.00 53.58 1.13 18.25 22.73 3.01 0.00 16.01 2.81 0.30 81.61 23.77 5.00 7.00 14.96 -35.27 154.11 -13.99 154.11	40 45 50 60	$\begin{array}{c} f_{G1o} \\ f_{G2i} \\ f_{G2i} \\ f_{L1} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ V \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{G1} \\ G2 \\ CRA_{obj} \\ (MIN) \\ CRA_{obj} \\ (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ \end{array}$	75.80 -26.89 21.02 62.82 15.66 -16.51 -7.43 18.11 25.89 -396.91 14.48 -14.11 -26.89 Example60 85.0 3.7 4.92 55.20 51.67 29.80 3.54 0.23 -1.33 10.62 18.57 10.87 48.94 1.25 17.64 32.78 3.28 0.00 16.87 8.57 0.30 81.61	39.79 -92.10 39.79 -92.10 39.79 20.87 13.01 -13.25 -9.05 17.01 27.28 15.71 -9.54 -92.10 Example61 88.4 2.2 7.93 86.88 74.30 1.54 12.58 0.60 -3.57 8.96 5.78 11.87 27.31 2.47 24.13 47.70 4.92 0.00 11.98 9.46 0.08 81.61	30.99 -10.89 30.99 -33.07 20.09 32.66 20.45 -10.48 -10.19 17.32 19.42 -19.26 -10.89 Example62 88.6 2.2 7.93 86.93 74.81 1.64 12.12 0.60 -3.56 8.92 5.87 11.92 27.45 2.34 24.30 48.17 4.96 0.00 12.41 9.47 0.07 81.61	31.29 -9.44 31.29 -30.71 19.65 29.48 19.15 -11.24 -8.32 12.55 -44.70 13.63 -9.44 Example63 60.2 1.3 4.75 59.29 53.77 0.88 5.52 0.60 -3.56 4.98 3.52 7.54 17.61 1.38 15.92 36.46 4.69 0.00 14.58 13.98 0.05 81.61

		215						2/0		
		-continued						-continued		
f_{G1}	18.97	10.24	10.30	6.64		L_{G1}	62.16	26.55	27.04	27.74
f_{G2}	364.23	18.57	18.54	11.47		L_{G2}	128.04	56.54	64.12	61.90
f_{G1o}	32.31	-22.52	-22.27	-25.76	5	$CRA_{obj}(MAX)$	4.70	4.94	4.99	5.01
f_{G2i}	-11.62	-34.87	-34.37	-17.38		CRA _{obj} (MIN)	0.00	0.00	0.00	0.00
f_{L1}	32.31 -41.97	-22.52 14.55	-22.27 14.55	-25.76 11.65		CRA _{img}	24.79 16.44	25.00 9.47	20.83 10.91	22.04 10.39
f_{L2}	-41.97 19.06	-58.25	-58.50	10.78		D _{max}	0.98	0.50	10.91	1.92
f_{L3} f_{L4}	20.24	14.89	14.91	10.76		D_{G1max} vd_{max}	81.61	81.61	81.61	81.61
f_{L5}	-12.81	12.86	12.99	-5.69		vd_{max} vd_{min}	23.78	23.78	23.78	23.78
f_{L6}	-13.01	-8.25	-8.28	-7.62	10	N_{G1}	8.00	8.00	8.00	7.00
\mathbf{f}_{L7}^{-L3}	16.75	-14.37	-14.41	10.65		Na	9.00	9.00	8.00	8.00
$f_{L8}^{L'}$	21.90	17.69	17.68	12.13		f_{G1}	26.67	12.77	13.05	13.53
f_{L9}	-24.06	17.56	17.51	17.05		f_{G2}	23.91	8.21	7.57	7.50
f_{L10}	15.59	-153.28	-146.40	-55.91		f_{G1o}	-23.95	-13.88	-23.63	-18.12
f_{L11}	-11.62	26.23	26.02	-17.38		f_{G2i}	-25.80	-9.16	-12.56	-11.98
\mathbf{f}_{L12}	_	-70.61	-71.96	_	15	\mathbf{f}_{L1}	-23.95	-13.88	-23.63	-18.12
f_{L13}	_	-34.87	-34.37	_		f_{L2}	47.51 34.71	26.64	49.63 16.80	31.61 14.76
	Example64	Example65	Example66	Example67		f_{L3} f_{L4}	92.60	17.87 49.61	50.11	19.71
	Lxampico+	LXampico5	Lxampicoo	Lxampico /		f_{L5}	40.59	19.99	21.35	-17.88
D_{oi}	68.2	64.9	63.7	121.9		f_{L6}	-37.87	-20.18	-17.12	15.83
Y_{obj}	1.5	1.5	1.5	3.0	20	f_{L7}	35.01	17.32	15.68	-13.95
Y	5.50	5.50	5.23	10.82	20	f_{L8}	-40.29	-14.74	-13.72	24.32
L_{TL}	67.34	63.81	62.20	119.67		f_{L9}	95.43	32.60	29.49	36.34
L_L	61.51	55.39	54.53	102.94		f_{L10}	63.05	27.51	30.46	-15.11
WD	0.88	1.13	1.49	2.27		f_{L11}	-34.09	-12.99	-15.53	33.42
BF	5.83	8.43	7.67	16.73		f_{L12}	69.13	30.92	33.80	80.48
NA	0.60	0.60	0.60	0.60	25	f_{L13}	193.42	64.33	78.99	20.12
β	-3.56	-3.56	-3.56	-3.55	23	f_{L14}	40.14	18.45	20.19	-14.40
f	5.34	6.16	5.82	12.29		f_{L15}	-26.47	-12.40	-13.04	-11.98
ϕ_{G1o}	3.94	4.11	4.39	8.06		f_{L16}	-699.77	33.28	-12.56	_
ϕ_s	8.63 19.86	8.68 20.47	8.89 19.69	16.50 37.57		f_{L17}	-25.80	-9.16		
D_{os}	1.62	1.96	1.60	3.57			Example72	Example73	Example74	Example75
$\mathrm{D}_{G1G2}^{\mathrm{G}}$ L_{G1}	18.02	18.09	17.27	32.88	30		L'Admpie / 2	Example 75	Example 74	Example 75
L_{G2}	41.87	35.34	35.65	66.49		$\overline{\mathrm{D}_{oi}}$	317.8	96.3	186.7	78.1
$CRA_{obj}(MAX)$	4.85	4.12	4.69	4.96		Y _{obj}	2.2	2.1	16.3	8.1
$CRA_{obi}(MIN)$	0.00	0.00	0.00	0.00		Y	7.93	7.39	21.63	10.82
CRA _{img}	15.70	13.05	13.18	12.17		L_{TL}	316.63	94.97	175.11	71.96
D_{max}	15.89	6.97	7.09	12.95		L_L	297.86	91.60	163.31	69.74
D_{G1max}	0.06	0.05	0.05	0.09	35	WD	1.15	1.28	11.55	6.14
vd _{max}	81.61	81.61	81.61	81.61		BF	18.77	3.37	11.80	2.22
vd_{min}										
	23.88	23.88	23.88	23.88		NA	0.81	0.80	0.23	0.23
N_{G1}	5.00	23.88 6.00	6.00	6.00		β	-3.56	-3.54	-1.33	-1.33
$N_{G1} \ N_{G2}$	5.00 6.00	23.88 6.00 7.00	6.00 7.00	6.00 7.00		$_{f}^{\beta}$	-3.56 23.68	-3.54 3.60	-1.33 23.92	-1.33 8.65
$egin{array}{l} \mathbf{N}_{G1} \ \mathbf{N}_{G2} \ \mathbf{f}_{G1} \end{array}$	5.00 6.00 7.65	23.88 6.00 7.00 7.39	6.00 7.00 7.62	6.00 7.00 14.27		$\begin{array}{c} \beta \\ f \\ \phi_{G1o} \end{array}$	-3.56 23.68 7.14	-3.54 3.60 6.93	-1.33 23.92 35.10	-1.33 8.65 19.15
$egin{array}{l} \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \end{array}$	5.00 6.00 7.65 12.69	23.88 6.00 7.00 7.39 13.38	6.00 7.00 7.62 13.36	6.00 7.00 14.27 25.41	40	$egin{array}{l} eta \ f \ lackbox{$\Phi_{\mathcal{G}1o}$} \ lackbox{Φ_s} \end{array}$	-3.56 23.68 7.14 50.87	-3.54 3.60 6.93 20.59	-1.33 23.92 35.10 25.14	-1.33 8.65 19.15 10.01
$egin{array}{l} \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1_o} \end{array}$	5.00 6.00 7.65 12.69 -34.83	23.88 6.00 7.00 7.39 13.38 -16.54	6.00 7.00 7.62 13.36 -17.90	6.00 7.00 14.27 25.41 -30.20	40	eta f ϕ_{G1o} ϕ_s D_{os}	-3.56 23.68 7.14 50.87 83.01	-3.54 3.60 6.93 20.59 30.70	-1.33 23.92 35.10 25.14 86.05	-1.33 8.65 19.15 10.01 32.23
$egin{array}{l} N_{G1} & & & & \\ N_{G2} & & & & \\ f_{G1} & & & & \\ f_{G2} & & & & \\ f_{G1o} & & & & \\ f_{G2i} & & & & \\ \hline \end{array}$	5.00 6.00 7.65 12.69 -34.83 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31	6.00 7.00 7.62 13.36 -17.90 -25.11	6.00 7.00 14.27 25.41 -30.20 -46.52	40	β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2}	-3.56 23.68 7.14 50.87 83.01 7.41	-3.54 3.60 6.93 20.59 30.70 0.05	-1.33 23.92 35.10 25.14 86.05 15.12	-1.33 8.65 19.15 10.01 32.23 5.76
$egin{array}{l} N_{G1} & & & & \\ N_{G2} & & & & \\ f_{G1} & & & & \\ f_{G2} & & & & \\ f_{G1o} & & & & \\ f_{G2i} & & & \\ f_{L1} & & & & \\ \end{array}$	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20	40	$\begin{array}{l} \beta \\ f \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98	-3.54 3.60 6.93 20.59 30.70 0.05 29.36	-1.33 23.92 35.10 25.14 86.05 15.12 60.91	-1.33 8.65 19.15 10.01 32.23 5.76 21.13
$egin{array}{ll} N_{G1} & N_{G2} & & & & \\ N_{G2} & & & & & \\ f_{G1} & & & & & \\ f_{G2} & & & & & \\ f_{G2i} & & & & \\ f_{L1} & & & & \\ f_{L2} & & & & \\ \end{array}$	5.00 6.00 7.65 12.69 -34.83 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31	6.00 7.00 7.62 13.36 -17.90 -25.11	6.00 7.00 14.27 25.41 -30.20 -46.52	40	β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1}	-3.56 23.68 7.14 50.87 83.01 7.41	-3.54 3.60 6.93 20.59 30.70 0.05	-1.33 23.92 35.10 25.14 86.05 15.12	-1.33 8.65 19.15 10.01 32.23 5.76
$egin{array}{ll} N_{G1} & N_{G2} & & & \\ I_{G2} & I_{G1} & & & & \\ I_{G2} & I_{G1o} & & & & \\ I_{G1i} & & & I_{G2i} & & \\ I_{L1} & & I_{L2} & & & \\ I_{L3} & & & & & \\ I_{C3} & & & & & \\ I_{C4} & & & & & \\ I_{C5} & & & & & \\ I_{C6} & & & & & \\ I_{C7} & & & & & \\ I_{C8} & & & & \\ I_{C8} & & & & \\ I_{C8} & & & & & \\ I_{C8} & & & & & \\ I_{C8} & & & \\ I_{C8} & & & & \\ I_{C8} & & & & \\ I_{C8} & & & & \\$	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97		$\begin{array}{l} \beta \\ f \\ \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1_o} f_{G2_i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89	40	$\begin{array}{l} \beta \\ f \\ \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{ymv} \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39		$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91
$egin{array}{ll} N_{G1} & N_{G2} & & & \\ N_{G2} & & & & \\ f_{G1} & & & & \\ f_{G2} & & & & \\ f_{G1o} & & & & \\ f_{G2i} & & & & \\ f_{L1} & & & & \\ f_{L2} & & & & \\ f_{L3} & & & & \\ f_{L4} & & & & \\ f_{L5} & & & & \\ f_{L6} & & & & \\ f_{L7} & & & & \\ \end{array}$	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62		$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65
$egin{array}{ll} N_{G1} & N_{G2} & & & \\ I_{G1} & & & & \\ I_{G2} & & & & \\ I_{G1o} & & & & \\ I_{G2i} & & & & \\ I_{L1} & & & & \\ I_{L2} & & & & \\ I_{L3} & & & & \\ I_{L3} & & & & \\ I_{L4} & & & \\ I_{L5} & & & & \\ I_{L6} & & & & \\ I_{L6} & & & & \\ I_{L7} & & & \\ I_{L8} & & & \\ I_{L8} & & & \\ I_{L8} & & & \\ I_{L8} & & & & \\ I_{L8} & & & \\ I_{L8} & & & \\ I_{L8} & $	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00		$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L5} f_{L6} f_{L7} f_{L8} f_{L9}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17		$\begin{array}{l} \beta \\ f \\ \\ f \\ \\ \\ \phi_{G1o} \\ \\ \phi_s \\ \\ D_{os} \\ \\ D_{os} \\ \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MMN) \\ CRA_{img} \\ D_{max} \\ D_{GImax} \\ vd_{max} \\ vd_{min} \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L9} f_{L9} f_{L10}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88	45	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L9} f_{L10}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44	45	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L9} f_{L10} f_{L11} f_{L11} f_{L11} f_{L11}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22	45	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L9} f_{L10}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44	45	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L9} f_{L10} f_{L11} f_{L11} f_{L11} f_{L11}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -26.31	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52	45	$\begin{array}{l} \beta \\ f \\ \\ f \\ \\ \\ \phi_{G1o} \\ \\ \phi_s \\ \\ D_{os} \\ \\ D_{os} \\ \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{GImax} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L9} f_{L10} f_{L11} f_{L11} f_{L11} f_{L11}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22	45	$\begin{array}{l} \beta \\ f \\ \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -3.414 -21.94
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L10} f _{L11} f _{L11}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -26.31	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52	45	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L10} f _{L11} f _{L11}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example 70	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71	45	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L7} f_{L8} f_{L8} f_{L10} f_{L11} f_{L12} f_{L13}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example 70	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71	45	$\begin{array}{l} \beta \\ f \\ \\ f \\ \\ \\ \phi_{S1o} \\ \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L11} f _{L11} f _{L11} f _{L12} f _{L11}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71	45	$\begin{array}{l} \beta \\ f \\ \\ f \\ \\ \\ \varphi_{G1o} \\ \\ \varphi_s \\ \\ D_{os} \\ \\ D_{os} \\ \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ \\ L_{G1} \\ L_{G2} \\ \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L110} f _{L111} f _{L12} f _{L13}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71	45	$\begin{array}{l} \beta \\ f \\ f \\ \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L10} f _{L112} f _{L112} f _{L12} f _{L13}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68 198.0 5.9 20.78 196.27	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71	45	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L10} f_{L11} f_{L12} f_{L13} f_{L13}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71	50	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87 -19.47	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96
$\begin{array}{c} N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ \\ \\ \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ \end{array}$	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68 198.0 5.9 20.78 196.27 192.17 1.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29 1.43	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83 1.35	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71 94.7 3.1 11.04 93.23 89.95 1.42	50	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30 62.19	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97 32.96	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87 -19.47 -38.56	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96 17.44
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2o} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L10} f _{L111} f _{L12} f _{L13} D _{oi} Y _{obj} Y L _{IL} UND BF	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68 198.0 5.9 20.78 196.27 192.17 1.76 4.10	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29 1.43 3.25	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83 1.35 3.30	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71 94.7 3.1 11.04 93.23 89.95 1.42 3.29	50	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30 62.19 64.81	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97 32.96 -25.57	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87 -19.47 -38.56 43.51	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96 17.44 24.71
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L112} f _{L13} D _{oi} Y _{obj} Y L _{TL} L _L WD BF NA	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68 198.0 5.9 20.78 196.27 192.17 1.76 4.10 0.60	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29 1.43 3.25 0.59	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83 1.35 3.30 0.62	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71 94.7 3.1 11.04 93.23 89.95 1.42 3.29 0.60	50	$\begin{array}{l} \beta \\ f \\ f \\ \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30 62.19 64.81 -115.85	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97 32.96 -25.57 22.34	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87 -19.47 -38.56 43.51 64.36	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96 17.44 24.71 29.65
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L10} f_{L11} f_{L12} f_{L13} D_{oi} Y_{obj} Y U_{LL}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68 198.0 5.9 20.78 196.27 192.17 1.76 4.10 0.60 -3.51	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29 1.43 3.25 0.59 -3.51	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83 1.35 3.30 0.62 -3.55	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71 94.7 3.1 11.04 93.23 89.95 1.42 3.29 0.60 -3.53	50	$\begin{array}{l} \beta \\ f \\ f \\ \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ \end{array}$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30 62.19 64.81 -115.85 251.10	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97 32.96 -25.57 22.34 -22.63	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87 -19.47 -38.56 43.51 64.36 67.19	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96 17.44 24.71 29.65 -29.20
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L10} f_{L11} f_{L12} f_{L13} D_{oi} Y_{obj} Y Y V_{obj}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29 1.43 3.25 0.59 -3.51 3.49	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83 1.35 3.30 0.62 -3.55 3.98	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71 94.7 3.1 11.04 93.23 89.95 1.42 3.29 0.60 -3.53 3.86	50	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30 62.19 64.81 -115.85 251.10 51.88	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97 32.96 -25.57 22.34 -22.63 64.58	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87 -19.47 -38.56 43.51 64.36 67.19 -95.92	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96 17.44 24.71 29.65 -29.20 29.95
N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L110} f _{L111} f _{L12} f _{L13} D _{oi} Y _{obj} Y L _{IL} WD BF NA β f Φ _{G1o} Φ _s	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68 198.0 5.9 20.78 196.27 192.17 1.76 4.10 0.60 -3.51 7.51 13.42	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29 1.43 3.25 0.59 -3.51 3.49 7.46	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83 1.35 3.30 0.62 -3.55 3.98 7.64	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71 94.7 3.1 11.04 93.23 89.95 1.42 3.29 0.60 -3.53 3.86 7.59	50	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30 62.19 64.81 -115.85 251.10 51.88	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97 32.96 -25.57 22.34 -22.63 64.58 29.63	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 37.85 -95.51 39.47 44.87 -19.47 -38.56 43.51 64.36 67.19 -95.92 62.16	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96 17.44 24.71 29.65 -29.20 29.95 -27.20
N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7} f_{L8} f_{L10} f_{L11} f_{L12} f_{L13} D_{oi} Y_{obj} Y Y V_{obj}	5.00 6.00 7.65 12.69 -34.83 -18.76 -34.83 13.39 12.27 12.09 -6.63 -8.89 12.18 14.00 19.50 -65.98 -18.76 Example68 198.0 5.9 20.78 196.27 192.17 1.76 4.10 0.60 -3.51 7.51 13.42 30.89	23.88 6.00 7.00 7.39 13.38 -16.54 -26.31 -16.54 10.73 -43.67 10.87 9.43 -6.05 -10.63 13.45 12.93 -146.69 21.08 -47.76 -26.31 Example69 89.0 3.1 10.82 87.54 84.29 1.43 3.25 0.59 -3.51 3.49 7.46 13.92	6.00 7.00 7.62 13.36 -17.90 -25.11 -17.90 10.83 -43.01 10.77 9.67 -6.14 -10.73 13.32 13.02 -94.00 20.56 -50.37 -25.11 Example70 96.5 3.1 11.04 95.13 91.83 1.35 3.30 0.62 -3.55 3.98 7.64 15.10	6.00 7.00 14.27 25.41 -30.20 -46.52 -30.20 19.97 -80.66 20.38 17.89 -11.39 -19.62 24.00 24.17 -241.88 36.44 -101.22 -46.52 Example71 94.7 3.1 11.04 93.23 89.95 1.42 3.29 0.60 -3.53 3.86 7.59 14.83	45 50 - - 55	$\begin{array}{l} \beta \\ f \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-3.56 23.68 7.14 50.87 83.01 7.41 78.98 211.47 1.62 0.00 5.18 65.37 1.28 81.61 23.88 5.00 7.00 30.45 60.53 -356.83 -23.54 -356.83 56.88 51.20 67.75 -35.65 -47.30 62.19 64.81 -115.85 251.10 51.88	-3.54 3.60 6.93 20.59 30.70 0.05 29.36 62.19 2.41 0.00 23.15 10.44 0.15 81.61 23.78 10.00 9.00 12.38 11.21 -63.28 -9.39 -63.28 69.53 36.72 25.98 44.35 -101.97 32.96 -25.57 22.34 -22.63 64.58 29.63 -16.59	-1.33 23.92 35.10 25.14 86.05 15.12 60.91 87.29 5.17 0.00 24.74 28.34 11.12 81.61 23.77 6.00 8.00 94.37 20.77 -54.58 -42.31 -54.58 37.85 -95.51 39.47 44.87 -19.47 -38.56 43.51 64.36 67.19 -95.92 62.16 -143.67	-1.33 8.65 19.15 10.01 32.23 5.76 21.13 42.85 4.99 -3.49 24.88 12.91 2.65 81.61 23.77 5.00 8.00 52.27 6.68 -34.14 -21.94 -34.14 24.01 22.73 33.81 -10.90 -18.96 17.44 24.71 29.65 -29.20 29.95 -27.20 -21.94

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1	7	0	
Z	1	o	

		-continued						-continued		
f_{L16}		21.08			•	f_{G2}	5.31	6.90	5.81	12.79
f_{L17}	_	-12.32	_	_		f_{G1o}	-49.08	-38.01	-394.66	-43.59
f_{L18}	_	26.62	_	_	5	f_{G2i}	-9.73	-7.49	-7.20	-28.44
f_{L19}	_	-9.39	_	_	3	f_{L1}	-49.08	-38.01	-394.66	-43.59
	Example76	Example77	Example78	Example79		f_{L2} f_{L3}	7.81 -12.93	8.01 -8.77	8.35 -11.94	20.83 -24.58
	E.manipie / o	Z.mainpre / /	Z.m.i.p.re / c	Z.m.pie / s		f_{L4}	10.12	7.77	10.11	36.17
D_{oi}	60.0	42.3	38.9	70.0		f_{L5}	6.12	7.51	7.13	31.43
\mathbf{Y}_{obj} \mathbf{Y}	5.6 7.46	4.0 5.33	3.6 4.75	2.2 4.92	10	f_{L6}	-3.71 -9.00	-4.59 -10.92	-4.14 -8.71	23.02 -13.86
$\stackrel{_{_{1}}}{\mathbb{L}_{TL}}$	55.44	39.54	36.46	54.21	10	$egin{aligned} \mathbf{f_{L7}} \\ \mathbf{f_{L8}} \end{aligned}$	-9.00 8.86	13.97	8.92	-15.60
$\overset{-1L}{L_L}$	50.94	36.43	33.86	51.58		f_{L9}	10.55	11.01	9.82	38.61
WD	4.57	2.77	2.40	15.80		f_{L10}	-21.47	68.51	-14.82	35.83
BF NA	4.49 0.23	3.11 0.22	2.60 0.23	2.63 0.38		f_{L11}	13.49 -17.07	-18.39 14.10	13.77 -7.20	45.75 -62.24
β	-1.34	-1.34	-1.33	-2.20	15	$f_{L12} \\ f_{L13}$	-17.07 -9.73	-7.49	-7.20 —	34.74
f	7.83	5.46	4.88	5.02	15	f_{L14}	_	_	_	-31.23
ϕ_{G1o}	12.21	8.66	7.73	16.73		f_{L15}	_	_	_	-28.44
Φ_s	7.44 26.76	5.16 19.94	4.66 18.00	11.57 32.14			Example84	Example85	Example86	Example87
\mathcal{D}_{os} \mathcal{D}_{G1G2}	3.57	3.42	2.99	0.96			Example 64	Exampleos	Exampleso	Examples /
L_{G1}	18.92	13.99	12.86	15.55	20	D_{oi}	28.4	35.3	33.0	40.0
L_{G2}	28.45	19.01	18.02	35.06	20	Y_{obj}	1.1	1.1	1.2	0.5
CRA _{obj} (MAX)	5.18 0.00	5.25 0.00	5.38 0.00	3.01 0.00		Y	2.82 24.89	2.86 31.65	2.30 29.34	2.23 39.37
CRA _{obj} (MIN) CRA _{img}	24.82	25.37	25.13	19.17		$egin{array}{c} egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}{c} \egin{array}$	18.91	28.14	26.24	33.75
D_{max}	11.11	5.30	4.58	8.48		WD	3.49	3.60	3.70	0.65
D_{Glmov}	2.70	1.82	1.35	0.10	25	BF	5.98	3.51	3.10	5.63
Vd _{max}	81.61	81.61	81.61	81.61	23	NA o	0.42	0.40	0.40	0.74
$\operatorname{vd}_{min}^{min}$ N_{G1}	23.77 6.00	23.77 6.00	23.77 6.00	23.77 6.00		β f	-2.54 5.60	-2.58 6.09	-1.99 5.65	-4.18 2.80
N_{G2}	8.00	8.00	8.00	7.00		Ф _{G10}	6.27	4.72	4.52	2.14
f_{G1}	32.52	18.20	16.26	14.02		Φ.	3.75	3.92	4.29	5.92
f_{G2}	6.32	5.06	4.49	919.29	30	D _{os}	11.35	11.28	11.56	9.99
f_{G1o} f_{G2i}	-24.61 -11.70	-15.40 -7.84	-13.03 -7.67	19.51 -20.20	30	D_{G1G2} L_{G1}	0.72 6.51	1.07 7.17	1.13 7.36	0.66 9.02
f_{L1}	-24.61	-15.40	-13.03	19.51		L_{G2}	11.68	19.90	17.75	24.07
f_{L2}	12.51	9.81	8.36	-30.65		$CRA_{obj}(MAX)$	0.57	3.42	4.40	0.56
f_{L3}	-19.58	-25.65	-22.64	25.01		CRA_{obi} (MIN)	0.00	0.00	0.00	0.00
f _{L4} f _{L5}	12.10 13.24	9.20 11.21	8.32 9.76	22.31 19.81	25	CRA_{img} D_{max}	9.96 2.78	10.12 4.34	10.38 3.45	10.98 3.51
f_{L6}	-6.06	-4.96	-4.28	-10.74	33	D_{G1max}	0.35	0.05	0.05	0.18
f_{L7}	-11.85	-10.26	-8.65	-10.27		Vd _{max}	81.54	81.61	81.61	81.61
f_{L8}	13.37	10.27	9.03	13.10		vd_{min}	30.30	23.88	23.88	23.88
$f_{L9} \\ f_{L10}$	20.64 21.90	16.03 16.67	14.04 14.68	22.47 -26.66		$N_{G1} \ N_{G2}$	4.00 6.00	5.00 6.00	5.00 6.00	5.00 6.00
f_{L11}	-29.72	-24.27	-20.66	12.62	40	f_{G1}	4.84	5.13	5.68	3.72
f_{L12}	20.98	15.70	13.61	-10.03	40	f_{G2}	6.71	8.69	7.57	4.86
f_{L13}	-122.15	-46.89	-27.17	-20.20		f_{G1o}	5.76	-20.67	-9.49	-23.50
f_{L14}	-11.70	-7.84	-7.67			f_{G2i} f_{L1}	-5.67 5.76	-18.30 -20.67	-16.04 -9.49	-12.20 -23.50
	Example80	Example81	Example82	Example83		f_{L2}	-28.93	7.74	7.53	6.67
					45	f_{L3}	5.78	6.64	5.45	5.74
D_{oi}	42.0	42.0	42.0	95.0	43	f_{LA}	-4.33	5.42	6.45	7.78
Y _{obj} Y	1.9 3.87	1.9 3.87	1.9 3.87	8.2 10.82		f_{L5} f_{L6}	4.34 -5.80	-3.10 -3.34	-3.50 -3.72	-4.03 -5.88
$\hat{\mathbb{L}}_{TL}$	39.50	39.51	39.51	88.69		f_{L7}	-39.03	4.70	5.20	6.11
\mathbb{L}_L	37.80	36.70	36.70	86.69		f_{L8}	130.77	7.31	6.96	8.22
WD BF	2.50	2.50	2.50	6.33 2.00	50	f_{L9}	4.80	-4.20	-4.61	-20.92
NA	1.70 0.32	2.81 0.32	2.81 0.32	0.33	50	$f_{L10} \\ f_{L11}$	-5.67 —	8.00 -18.30	7.57 -16.04	25.26 -12.20
β	-2.00	-2.00	-2.00	-1.32		-L11		10,00	10.0	12.20
f	3.72	4.27	4.22	9.91			Example88	Example89	Example90	Example91
ф _{G10}	4.74	4.79	4.79	17.51		D	31.5	53.0	59.0	57.0
Φ_s D_{os}	4.35 16.30	4.32 16.95	4.41 16.10	16.65 46.23	55	$\begin{array}{c} \mathbf{D}_{oi} \\ \mathbf{Y}_{obj} \end{array}$	0.5	0.3	1.4	57.0 1.1
D_{G1G2}	2.34	2.31	2.42	7.49	33	Y	2.30	2.30	2.82	2.25
L_{G1}	12.41	13.22	12.19	33.79		L_{TL}	30.83	52.83	55.01	53.01
L_{G2}	23.05	21.17	22.09	45.40		L_{L}	26.99	37.38	50.04	48.35
$CRA_{obj}(MAX)$	5.09	5.06	5.07	5.49		WD	0.66	0.21	4.00	4.00
CRA _{obj} (MIN)	0.00	0.00	0.00	0.00	60	BF NA	3.84 0.75	15.45 0.95	4.97 0.39	4.66
CRA_{img} D_{max}	21.91 4.64	21.91 4.93	21.76 5.73	25.15 19.80	υU	NA β	-4.18	-8.37	-2.04	0.41 -2.04
D_{max} D_{G1max}	0.46	0.45	0.28	6.49		f	1.99	2.62	10.15	9.96
vd _{max}	81.61	81.61	81.61	81.61		Φ_{G1o}	2.11	1.51	5.57	5.37
vd_{min}	23.77	23.77	23.77	23.77		Φ_s	5.46	8.61	7.00	7.05
N_{G1}	6.00	6.00	6.00	7.00	(=	D_{os}	8.62	11.27	27.30	25.23
N_{G2}	7.00	7.00	6.00	8.00	65	- 0102	0.16	0.49	2.28	2.12
f_{G1}	7.77	7.39	8.00	29.25		L_{G1}	7.80	10.95	21.12	19.21

-continued						280		
						-contin	nued	
L_{G2}	19.03	25.94	26.64	27.02	•	L_L	38.30	
$CRA_{obj}(MAX)$	1.33	0.00	2.29	0.88		WD	2.00	
CRA _{obi} (MIN)	0.00	-1.04	0.00	0.00	_	BF	1.70	
CRA_{img}	15.86	6.11	5.62	5.61	5	NA	0.32	
D_{max}	3.54	3.75	4.23	4.14		$eta _{ m f}$	-2.00	
D_{G1max}	0.05	0.05	2.85	3.46			3.71	
vd_{max}	81.61	81.61	94.93	94.93		Φ_{G1o}	4.88	
vd_{min}	23.88	23.88	23.78	23.78		Φ_s	5.76	
N_{G1}	5.00	5.00	6.00	6.00		D_{os}	14.98	
N_{G2}	6.00	7.00	7.00	7.00	10	D_{G1G2}	1.17	
f_{G1}	3.45	3.49	9.19	8.65		L_{G1}	12.88	
f_{G2}	4.02	6.12	14.39	11.93		L_{G2}	24.25	
f_{G1o}	-16.97	-188.41	-5.35	-5.97		$CRA_{obj}(MAX)$	1.23	
f_{G2i}	-8.79	-13.18	10.98	17.06		$CRA_{obj}(MIN)$	0.00	
f_{L1}	-16.97	-188.41	-5.35	-5.97		CRA_{img}	23.29	
f_{L2}	6.44	7.75	7.52	7.45	15	D_{max}	4.22	
f_{L3}	5.26	6.11	15.14	14.61		D_{G1max}	2.00	
f_{L4}	6.83	9.89	16.17	12.63		vd_{max}	81.61	
f_{L5}	-4.18	-6.16	22.58	65.83		vd_{min}	23.77	
f_{L6}	-5.93	-8.03	-6.08	-6.36		N_{G1}	8.00	
f_{L7}	5.06	9.89	-8.66	-9.70		N_{G2}	7.00	
f_{L8}	7.73	12.25	8.05	7.95	20	f_{G1}	8.77	
f_{L9}	-10.04	16.32	9.42	9.41	20	f_{G2}	5.85	
f_{L10}	12.64	-13.51	-5.50	-5.29		f_{G1o}	42.78	
f_{L11}	-8.79	20.30	9.06	8.00		\mathbf{f}_{G2i}	-11.46	
f_{L12}	_	-13.18	-7.93	-9.17		f_{L1}	42.78	
f_{L13}	_	_	10.98	17.06		f_{L2}	8.79	
					25	f_{L3}	38.11	
	Example92	Example93	Example94	Example95	23	f_{L4}	7.09	
					•	f_{L5}	-13.77	
D_{oi}	81.0	57.0	81.0	42.0		f_{L6}	-8.18	
Y_{obj}	0.5	1.1	0.5	1.9		f_{L7}	9.73	
Y	2.25	2.25	2.25	3.87		f_{L8}	11.92	
L_{TL}	80.01	53.00	80.01	39.99	•	f_{L9}	-61.27	
L_L	75.35	48.35	74.89	38.29	30	$ m f_{L10}$	13.10	
WD	1.00	4.00	1.00	2.01		f_{L11}	-8.77	
BF	4.66	4.65	5.13	1.70		f_{L12}	-11.46	
NA	0.74	0.40	0.69	0.32				
β	-4.09	-2.04	-4.09	-2.00		FIG 404: 1' '		
f	6.29	9.83	6.84	3.75		FIG. 104 is a diagram showi		
Φ _{G10}	3.08	5.24	2.90	4.91	35	optical instrument according to	the present embodiment.	
Φ_s	8.97	6.91	8.13	5.58		microscope 1 is a microscope of		
D_{os}	25.76	25.31	25.47	13.92				
D_{G1G2}	2.90	2.07	3.59	1.16		FIG. 104, the microscope 1 includes	• • •	
L_{G1}	21.96	19.34	21.84	11.81		an image pickup section 4, an il	luminating unit 5, an aimin	

an Α in 3, an image pickup section 4, an illuminating unit 5, an aiming knob 6, an optical system 7, and an image pickup element 8.

The main body 2 is provided with the stage 3, the image pickup section 4, and the aiming knob 6. A sample is placed on the stage 3. Movement of the stage 3 in an optical axial direction is carried out by the aiming knob 6. The stage 3 is $_{45}$ moved by an operation (rotation) of the aiming knob $\bf 6$, and accordingly, focusing with respect to the sample is possible. For this, a moving mechanism (not shown in the diagram) is provided between the main body 2 and the stage 3.

The image pickup section 4 is provided with the illuminat-50 ing unit 5. The image pickup section 4 and the illuminating unit 5 are positioned above the stage 3. An illuminating element 5a is disposed to be in a ring shape in the illuminating unit 5. An LED is an example of the illuminating element 5a.

The optical system 7 and the image pickup element 8 are 55 disposed at an interior of the image pickup section 4. The optical system according to the example 1 for instance, is used for the optical system 7. The optical system 7 includes an objective 7a (the lens unit Gf or the first lens unit) and a tube lens 7b (the lens unit Gr or the second lens unit). A front end 60 of the objective 7a is positioned at a central portion of the illuminating unit 5.

Illuminating light is irradiated from the illuminating unit 5. In this case, the illumination is an epi-illumination. Light reflected from the sample travels through the optical system 7 65 and is incident on the image pickup element 8. A sample image (optical image) is formed on an image pickup surface of the image pickup element 8. The sample image is subjected

D_{oi}	81.0	57.0	81.0	42.0
Y_{obj}	0.5	1.1	0.5	1.9
Y	2.25	2.25	2.25	3.87
L_{TL}	80.01	53.00	80.01	39.99
L_L^{LL}	75.35	48.35	74.89	38.29
wD	1.00	4.00	1.00	2.01
BF	4.66	4.65	5.13	1.70
NA	0.74	0.40	0.69	0.32
β	-4.09	-2.04	-4.09	-2.00
f	6.29	9.83	6.84	3.75
ϕ_{G1o}	3.08	5.24	2.90	4.91
ϕ_s	8.97	6.91	8.13	5.58
D_{os}	25.76	25.31	25.47	13.92
D_{G1G2}	2.90	2.07	3.59	1.16
L_{G1}	21.96	19.34	21.84	11.81
L_{G2}	50.49	26.94	49.45	25.32
CRA _{obi} (MAX)	0.00	0.99	0.00	1.21
CRA _{obj} (MIN)	-1.16	0.00	-2.31	0.00
CRA _{img}	5.61	5.61	5.58	23.82
D _{max}	17.45	4.13	18.98	4.73
DG1 _{max}	0.10	3.79	3.68	2.81
vd _{max}	81.61	94.95	81.61	81.61
vd_{min}	23.78	23.78	23.78	23.77
N_{G1}	6.00	6.00	5.00	7.00
N_{G2}	6.00	7.00	6.00	7.00
f_{G1}	5.80	8.93	5.58	8.64
f_{G2}	15.76	11.67	18.54	5.35
f_{G1o}	-12.63	-6.06	13.76	28.96
f_{G2i}	-64.25	16.31	-53.92	-10.77
f_{L1}	-12.63	-6.06	13.76	28.96
f_{L2}	8.98	7.53	25.11	7.91
f_{L3}	31.87	14.85	29.18	6.66
f_{L4}	30.81	13.01	8.68	-10.48
f_{L5}	9.29	66.65	-5.84	-7.74
f_{L6}	-6.10	-6.38	-7.71	9.09
f_{L7}	-10.23	-10.84	9.91	11.82
f_{L8}	12.17	8.38	24.46	-61.10
f_{L9}	19.79	9.37	-27.09	13.27
	-35.91	-5.19	20.16	-9.57
f_{L10}	-33.91 24.54		-53.92	-9.37 -10.77
f_{L11}		8.16	-33.92	-10.77
f_{L12}	-64.25	-9.11	_	_
f_{L13}	_	16.31	_	

 \mathcal{L}_{TL}

Example96

42.0

1.9

3.87

40.00

to photoelectric conversion by the image pickup element **8**, and accordingly, an image of the sample is achieved. The image of the sample is displayed on a display unit (not shown in the diagram). In such manner, an observer is able to observe the image of the sample.

Here, the microscope 1 includes the optical system. 7 (the optical system according to the present embodiment). In this optical system 7, the numerical aperture on the image side is large, and various aberrations are corrected favorably. Therefore, in the microscope 1, various aberrations are corrected favorably, and a bright and sharp sample image is achieved.

In the example described above, the optical system was disposed in the image pickup section. However, the arrangement is not restricted to such an arrangement. For example, in an objective (the lens unit Gf or the first lens unit) for which, 15 a parfocal distance is 75 mm, it is possible to dispose the optical system and the image pickup element of the present example in a frame member which holds lenses. In this case, it is possible to install the optical system according to the present embodiment to the revolver similarly as the existing 20 objective lens. When such an arrangement is made, it is possible to use the existing objective lens (the lens unit Gf or the second lens unit) and the optical system according to the present embodiment upon switching over.

Moreover, the description has been made by using the 25 example of the microscope as the optical instrument using the abovementioned optical system. However, the optical system according to the present invention is not restricted to the microscope, for example, the optical system according to the present invention is applicable to an electronic image pickup 30 apparatus (a lens unit for a portable camera, a notebook computer, and a handheld information terminal) as an optical instrument.

Since the image pickup section 4 includes the image pickup element 8, it is possible to assume the image pickup 35 section 4 as an image pickup apparatus. In this case, since a microscope 1 includes the image pickup section 4, the stage 3, and the illuminating unit 5, it can be referred to as an image pickup system. In FIG. 104, the stage 3 is connected to the main body 2 via the aiming mechanism (aiming knob 6). 40 However, the stage 3 may be installed directly on the main body without installing via a moving mechanism. By making such an arrangement, it is possible to integrate the image pickup section 4 and the stage 3 via the main body 2.

FIG. **105** is a diagram showing a microscope which is the 45 optical instrument of the present embodiment. A microscope **10** is a microscope of the upright type. Same reference numerals are assigned to components which are same as in the microscope **1** (FIG. **104**), and description of such components is omitted.

An optical system 11 and the image pickup element 8 are disposed at the interior of the image pickup section 4. The optical system according to the example 8 for instance, is used for the optical system 11. The optical system 11 includes a first lens unit 11a (or the lens unit Gf) and the second lens 55 unit 11b (or the lens unit Gr).

In the microscope 1, the illuminating unit 5 has been provided toward the optical system 7. Whereas, in the microscope 10, an illuminating unit 12 is provided on an opposite side of the optical system 11, sandwiching the stage 3 60 between the illuminating unit 12 and the optical system 11. The illuminating unit 12 includes a light source section 13 and a light guiding fiber 14.

The light source section 13 includes a light source such as a halogen lamp, a mercury lamp, a xenon lamp, an LED (light 65 emitting diode), or a laser. Moreover, the light source section 13 includes a lens. Illuminating light emitted from the light

source is incident on an inlet end 15 of the light guiding fiber 14. The illuminating light incident on the light guiding fiber 14 is transmitted through the light guiding fiber 14, and is

emerged from an exit end 16.

The exit end 16 of the light guiding member 14 is connected to the stage 3 by a holding mechanism (not shown in the diagram). Here, the exit end 16 of the light guiding fiber 14 is positioned on a lower surface of the stage 3. Therefore, the illuminating light emerged from the exit end 16 is directed from a lower side of the stage 3 toward the optical system 11, and is irradiated to the sample. In this manner, transmitted illumination is carried out in the microscope 10.

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Here, the light guiding fiber 14 is held by the stage 3. However, the light guiding fiber 14 may be held by a means other than the stage 3. Moreover, the exit end 16 of the light guiding member 14 may be positioned on an upper surface (the optical system 7 side) of the stage 3. By making such an arrangement, it is possible to carry out the epi-illumination in the microscope 10 similarly as in the microscope 1.

Transmitted light from the sample travels through the optical system 11 and is incident on the image pickup element 8. A sample image (an optical image) is formed on the image pickup surface of the image pickup element 8. The sample image is subjected to photoelectric conversion by the image pickup element 8, and accordingly, an image of the sample is achieved. The image of the sample is displayed on a display unit (not shown in the diagram). In such manner, the observer is able to observe the image of the sample.

The microscope 10 also includes the optical system 11 (the optical system according to the present embodiment). The optical system 11 is an optical system in which aberrations are corrected favorably, while being an optical system having a short overall length, and has a high resolution because of the favorable correction of aberrations. Therefore, in the microscope 10, various aberrations are corrected favorably, and a sample image in which, the microscopic structure is clear, is achieved. The illumination of the microscope 10 may be epi-illumination. Moreover, it is possible to make design modifications appropriately in an arrangement of members which form the microscope 10.

FIG. 106 is a diagram showing a microscope which is an optical instrument of the present embodiment. A microscope 20 is a microscope of an inverted type. The microscope 20 includes a main body 21, a stage 22, the image pickup section 4, an optical system 23, the image pickup element 8, an aiming knob 24, a transmitted illumination light source 25, a reflecting mirror 26, and a condenser lens 27.

Here, the optical system 23 and the image pickup element 8 are disposed at the interior of the image pickup section 4.

For the optical system 23, an optical system such as the optical system according to the example 20 is used. The optical system 23 includes a first lens unit (or the lens unit Gf) 23a and a second lens unit (or the lens unit Gr) 23b.

The main body 21 is provided with the stage 22, the image pickup section 4, and the aiming knob 24. A sample is placed on the stage 22. Movement of the image pickup section 4 in the optical axial direction is carried out by the aiming knob 24. The image pickup section 4 is moved by an operation (rotation) of the aiming knob 24, and accordingly, focusing with respect to the sample is possible. For this, a moving mechanism (not shown in the diagram) is provided inside the main body 21, and the image pickup section 4 is held by the moving mechanism.

Moreover, the main body 21 is provided with the transmitted illumination light source 25, the reflecting mirror 26, and the condenser lens 27. The transmitted illumination light source 25, the reflecting mirror 26, and the condenser lens 27

are disposed above the stage 22. Illuminating light emitted from the transmitted illumination light source 25 is reflected at the reflecting mirror 26, and is incident on the condenser lens 27. The condenser lens 27 is positioned above an upper surface of the stage 22. Accordingly, illuminating light 5 emerged from the condenser lens 27 is directed from an upper side of the stage 22 toward the optical system 23, and is irradiated to the sample. In such manner, the transmitted illumination is carried out in the microscope 20.

The microscope **20** also includes the optical system **23** 10 (optical system according to the present embodiment). The optical system **23** is an optical system in which aberrations are corrected favorably, while being an optical system having a short overall length, and has a high resolution because of the favorable correction of aberrations. Therefore, in the microscope **20**, various aberrations are corrected favorably, and a sample image in which, the microscopic structure is clear, is achieved. It is possible to make design modifications appropriately in an arrangement of members which form the microscope **20**.

FIG. 107A and FIG. 107B are diagrams showing a microscope which is an optical instrument of the present embodiment. FIG. 107A is a diagram showing an arrangement of the microscope, and FIG. 107B is a diagram showing a state in which, a microscope 30 is fixed.

The microscope 30 is a microscope of a portable type. The microscope 30 includes a probe section 31, a control box 32, a light guiding fiber 33, a cable 34, the image pickup section 4, an optical system 35, the image pickup element 8, a light guiding body for illumination 36, and a light source 37.

The optical system **35** and the image pickup element **8** are disposed at the interior of the image pickup section **4**. For the optical system **35**, an optical system such as the optical system according to the example 61 is used. The optical system **35** includes a first lens unit (or the lens unit Gf), **35***a* and a 35 second lens unit (or the lens unit Gr) **35***b*.

The probe section 31 and the control box 32 are connected by the light guiding fiber 33 and the cable 34. The control box 32 includes the light source 37 and a processing section (not shown in the diagram). The processing section processes a 40 video signal from the probe section 31.

The probe section 31 is of a size that enables a user to hold the probe section 31 in a hand. The probe section 31 includes the image pickup section 4 and the light guiding body for illumination 36. The light guiding body for illumination 36 is 45 disposed at an outer peripheral side of the image pickup section 4. The light guiding body for illumination 36 is optically connected to the light guiding fiber 33. Illuminating light emitted from the light source 37 is transmitted through the light guiding fiber 33, and is incident on the light guiding 50 body for illumination 36. The illuminating light is transmitted through the light guiding body for illumination, and is emerged from the probe section 31. In such manner, the epi-illumination is carried out in the microscope 30.

Light reflected from the sample travels through the optical 55 system 35 and is incident on the image pickup element 8. A sample image (an optical image) is formed on the image pickup surface of the image pickup element 8. The sample image is subjected to photoelectric conversion by the image pickup element 8, and accordingly, an image of the sample is achieved. The image of the sample is displayed on the display unit (not shown in the diagram). In such manner, the observer is able to observe the image of the sample.

The probe section **31** is connected to the control box **32** by the light guiding fiber **33** and the cable **34**. Therefore, it is 65 possible to set a position and a direction of the probe **31** freely. In this case, fixing of a posture (position and direction) of the

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probe section 31 is to be carried out by hands of the observer. However, in fixing by the hands of the observer, sometimes there is no sufficient stability.

For stabilizing the posture (position and direction) of the probe section 31, it is preferable to hold the probe section 31 by a mount 38 as shown in FIG. 107B. By doing so, it is possible to stabilize the posture of the probe section 31.

The mount 38 is provided with an aiming knob 39. Movement of the probe section 31 (image pickup section 4) in the optical axial direction is carried out by the aiming knob 39. The probe section 31 is moved by an operation (rotation) of the aiming knob 39, and accordingly, focusing with respect to the sample is possible. For this, a moving mechanism (not shown in the diagram) is provided inside the mount 38.

The microscope 30 also includes the optical system 35 (optical system according to the present embodiment). The optical system 35 is an optical system in which aberrations are corrected favorably, while being an optical system having a short overall length, and has a high resolution because of the favorable correction of aberrations. Therefore, in the microscope 30, various aberrations are corrected favorably, and a sample image in which, the microscopic structure is clear, is achieved. It is possible to make design modifications appropriately in an arrangement of members which form the microscope 30.

In each of the microscope 1, the microscope 10, the microscope 20, and the microscope 30, any optical system from among the optical systems according to the example 1 to the example 96 can be used.

In such manner, the present invention may have various modified examples without departing from the scope of the invention. Shapes and the number of lenses are not restricted to the shapes and the number indicated in the examples described heretofore. A lens which is not shown in the diagrams of the examples described heretofore, and which essentially has no refractive power may be disposed.

According to the present invention, it is possible to provide an optical system in which, an aberration is corrected favorably, and the overall length is short while having a high resolution due to the favorable aberration correction, and an image pickup apparatus, and an image pickup system in which such optical system is used. Moreover, according to the present invention, it is possible to provide an optical system in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably, and an optical instrument in which, such optical system is used.

The present invention also includes the following inventions in addition to the abovementioned inventions. (Appended Mode 1-1)

An optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side.

a first lens unit having a positive refractive power, which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

the following conditional expressions (15), (16), (19), and (20) are satisfied:

$$\beta \leq -1.1$$
 (15)

$$0.08 < NA$$
 (16)

$$1.0 \le WD/BF$$
 (19)

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 4.0$$
 (20)

where.

 β denotes an imaging magnification of the optical system, NA denotes a numerical aperture on the object side of the

optical system,
WD denotes a distance on an optical axis from the object up

to an object-side surface of the first object-side lens, BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the image,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a maximum object here ϕ_s denotes a diameter of the stop.

(Appended Mode 1-2)

The optical system according to appended mode 1-1, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (31) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.5$$
 (31) 30

where,

 ${\cal L}_{G1}$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 L_{G2} denotes a distance on the optical axis from an object- 35 side surface of the second object-side lens up to an image side surface of the second image-side lens.

(Appended Mode 1-3)

The optical system according to one of appended modes 1-1 and 1-2, wherein the following conditional expression 40 (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

 ${\rm D}_{os}$ denotes a distance on the optical axis from the object up $_{45}$ to the stop, and

 \mathbf{D}_{oi} denotes a distance on the optical axis from the object up to the image.

(Appended Mode 1-4)

The optical system according to one of appended modes 50 1-1 to 1-3, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where,

 ${\rm L}_L$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens, and

 \mathbf{D}_{ot} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 1-5)

The optical system according to one of appended modes 1-1 to 1-4, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

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where.

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop, and

 \mathcal{L}_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 1-6)

(16) The optical system according to one of appended modes 1-1 to 1-5, wherein the following conditional expression (21) (19) 10 is satisfied:

$$0.01 < D_{max} / \phi_s < 3.0$$
 (21)

where

 D_{max} denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 1-7)

The optical system according to one of appended modes 1-1 to 1-6, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_I/D_{oi} + 0.07 \times WD/BF$$
 (56)

where.

 ${\rm L}_{L}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 1-8)

The optical system according to one of appended modes 1-1 to 1-7, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
 = 0.39×WD/BF < 1.8 (57)

where.

 D_{os} denotes the distance on the optical axis from the object up to the stop,

 ${\cal L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 1-9)

The optical system according to one of appended modes 1-1 to 1-8, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, 60 and

 ${\rm L}_L$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 1-10)

The optical system according to one of appended modes 1-1 to 1-9, wherein the following conditional expressions (35) and (36) are satisfied:

(35)

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 $1.0 < D_{ENP} / Y$

$$0 \le CRA_{obj}/CRA_{img} \le 0.5 \tag{36}$$

 D_{ENP} denotes a distance on the optical axis from a position ⁵ of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical system,

 CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 CRA_{img} denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended Mode 1-11)

An optical system according to one of appended modes 1-1 20 to 1-10, wherein

a conjugate image of an object is formed by the first lens unit, and

a final image of the object is formed by the second lens unit,

the following conditional expression (18) is satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1de} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) / \epsilon_d < 30$$
 (18)

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image 35 point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in 40 which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 f_{G2C} denotes a focal length for the C-line of the second lens unit, and

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the

the object point and the image point are points on the optical axis, and also include cases of being a virtual object 55 point and a virtual image point.

(Appended Mode 1-12)

The optical system according to one of appended modes 1-1 to 1-11, wherein the following conditional expression (22) is satisfied:

$$0.01 \le D_{G1max}/\phi_s \le 2.0$$
 (22)

where.

 D_{G1max} denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens 65 disposed nearest to the image side, and unit, and

 ϕ_s denotes the diameter of the stop.

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(Appended Mode 1-13)

The optical system according to one of appended modes 1-1 to 1-12, wherein the following conditional expression (24) is satisfied:

$$0.01 < 1/v d_{min} - 1/v d_{max}$$
 (24)

where.

vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and vd_{max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the optical system. (Appended Mode 1-14)

The optical system according to one of appended modes 1-1 to 1-13, wherein the following conditional expression (26) is satisfied:

$$0.95 < \phi_{GLo}/(2 \times Y/|\beta|) \tag{26}$$

where.

 ϕ_{G10} denotes an effective diameter of the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical system, and

 β denotes the imaging magnification of the optical system. (Appended Mode 1-15)

The optical system according to one of appended modes 1-1 to 1-14, wherein the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where.

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image,

Y denotes the maximum image height in the overall optical system.

(Appended Mode 1-16)

The optical system according to one of appended modes 1-1 to 1-15, wherein the following conditional expression (29) is satisfied:

$$-0.2 < \phi_{G1o}/R_{G1o} < 3.0$$
 (29)

 ϕ_{G1o} denotes the effective diameter of the object-side surface of the first object-side lens, and

 R_{G10} denotes a radius of curvature of the object-side surface of the first object-side lens.

(Appended Mode 1-17)

The optical system according to one of appended modes 1-1 to 1-16, wherein

the second lens unit includes four lenses, and

at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and

an object-side surface of the positive lens from among the positive lenses, which is positioned nearest to the object side, 60 is a convex surface that is convex toward the object side. (Appended Mode 1-18)

The optical system according to one of appended modes 1-1 to 1-17, wherein

the first lens unit includes a first image-side lens which is

a distance of two lenses positioned on two sides of the stop is fixed, and

the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

where,

 ${\rm D}_{G1G2}$ denotes a distance on the optical axis from the 5 image-side surface of the first image-side lens up to the object-side surface of the second object-side lens, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 1-19)

The optical system according to one of appended modes 10 1-1 to 1-18, wherein the following conditional expression (32) is satisfied:

$$0.1 \le L_{G1s}/L_{sG2} \le 1.5$$
 (32)

where

 \mathcal{L}_{G1s} denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the stop, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens. (Appended Mode 1-20)

The optical system according to one of appended modes 1-1 to 1-19, wherein the following conditional expression (33) is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0$$
 (33)

where,

 ϕ_{G1max} denotes a maximum effective diameter from among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among effective diameter of lenses in the second lens unit. (Appended Mode 1-21)

The optical system according to one of appended modes 1-1 to 1-20, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where,

 D_{os} denotes the distance on the optical axis from the object 40 1-1 to 1-27, wherein up to the stop, and the second lens u

 ${\cal L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 1-22)

The optical system according to one of appended modes 1-1 to 1-21, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \leq CRA_{ob}/CRA_{img} \leq 0.5 \tag{36}$$

where.

 D_{ENP} denotes the distance on the optical axis from a position of an entrance pupil of the optical system up to the 55 object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical system.

 CRA_{obj} denotes the maximum angle from among angles made by a principal ray that is incident on the first object-side 60 lens, with the optical axis, and

 ${\rm CRA}_{img}$ denotes the maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let 65 wherein to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle.

65 wherein a positive angle predeter

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(Appended Mode 1-23)

The optical system according to one of appended modes 1-1 to 1-22, wherein

the first lens unit includes the first object-side lens, and a lens which is disposed to be adjacent to the first object-side lens, and

at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.

(Appended Mode 1-24)

The optical system according to one of appended modes 1-1 to 1-23, wherein the first object-side lens has a positive refractive power.

(Appended Mode 1-25)

The optical system according to one of appended modes 1-1 to 1-24, wherein the following conditional expression (37) is satisfied:

$$0.05 < f_{G1} / f$$
 (37)

where.

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 f_{Glo} denotes a focal length of the first object-side lens, and f denotes a focal length of the overall optical system.

(Appended Mode 1-26)

(33) The optical system according to one of appended modes 1-1 to 1-25, wherein an object-side surface of the first object-side lens is convex toward the object side.

(Appended Mode 1-27)

The optical system according to one of appended modes 1-1 to 1-26, wherein the following conditional expression 30 (38) is satisfied:

$$0.02 < R_{GL} / WD \tag{38}$$

where.

 R_{G1o} denotes the radius of curvature of the object-side 35 surface of the first object-side lens, and

WD denotes the distance on the optical axis from the object up to the object-side side surface of the first object-side lens. (Appended Mode 1-28)

The optical system according to one of appended modes

the second lens unit includes a predetermined lens unit nearest to the image, and

the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and

the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

50 (Appended Mode 1-29)

The optical system according to one of appended modes 1-1 to 1-28, wherein

an image-side surface of the second image-side lens is concave toward the image side, and

the following conditional expression (39) is satisfied:

$$0.1 < R_{G2}/BF$$
 (39)

where,

 $R_{\mathcal{G}^{2l}}$ denotes a radius of curvature of the image-side surface of the second image-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 1-30)

The optical system according to appended mode 1-28, wherein

a positive lens is disposed toward the object side of the predetermined lens unit, and

the positive lens is disposed to be adjacent to the predetermined lens unit.

(Appended Mode 1-31)

The optical system according to one of appended modes 1-1 to 1-30, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

the following conditional expression (40) is satisfied:

$$0.2 < R_{G17} / D_{G1is}$$
 (40)

where.

 R_{GII} denotes a radius of curvature of the image-side surface of the first image-side lens, and

 D_{Glis} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop. (Appended Mode 1-32)

The optical system according to one of appended modes 1-1 to 1-31, wherein the following conditional expression (41) is satisfied:

$$0.5 < f_{G1} / f_{G1} < 20$$
 (41)

where.

 f_{G1o} denotes the focal length of the first object-side lens,

 f_{G1} denotes a focal length of the first lens unit.

(Appended Mode 1-33)

The optical system according to one of appended modes 30 1-1 to 1-32, wherein the following conditional expression (42) is satisfied:

$$0.01 < 1/v d_{G1min} - 1/v d_{G1max}$$
 (42)

where.

 vd_{G1min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the first lens unit, and

vd_{G1max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the first lens unit.

(Appended Mode 1-34)

The optical system according to one of appended modes 1-1 to 1-33, wherein the following conditional expression (43) is satisfied:

$$0.01 < 1/v d_{G2min} - 1/v d_{G2max}$$
 (43)

 vd_{G2min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and

 vd_{G2max} denotes a largest Abbe's number from among 50 Abbe's numbers for lenses forming the second lens unit. (Appended Mode 1-35)

The optical system according to one of appended modes 1-1 to 1-34, wherein the optical system includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where.

 θ_{gF} denotes a partial dispersion ratio of the positive lens, 60 and is expressed by $\theta_{gF} = (ng-nF)/(nF-nC)$, where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

(Appended Mode 1-36)

The optical system according to appended mode 1-35, 65 wherein the positive lens which satisfies conditional expression (44) is included in the first lens unit.

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(Appended Mode 1-37)

The optical system according to one of appended modes 1-35 and 1-36, wherein the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s}/L_{G1s} \le 1$$
 (45)

where.

 D_{p1s} denotes a distance on the optical axis from an object- $_{10}$ side surface of the positive lens up to the stop, and

 L_{G1s} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the stop. (Appended Mode 1-38)

The optical system according to one of appended modes 1-1 to 1-37, wherein the optical system includes at least one diffractive optical element.

(Appended Mode 1-39)

The optical system according to one of appended modes 1-1 to 1-38, wherein at least one diffractive optical element is disposed at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 < D_{DLs}/D_{G1is}$$
 (48)

25

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 D_{DLs} denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 D_{G1is} denotes the distance on the optical axis from the image-side surface of the first image-side lens up to the stop. (Appended Mode 1-40)

The optical system according to one of appended modes 1-1 to 1-39, wherein at least one diffractive optical element is disposed at a position which is on the image side of the stop, and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

 D_{sDL} denotes a distance on the optical axis from the stop up to the diffractive optical element, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens. (Appended Mode 1-41)

The optical system according to one of appended modes 1-1 to 1-40, wherein the optical system includes a negative (43) 45 lens which satisfies the following conditional expressions (50) and (51):

$$0.01 < 1/v d_{n1} - 1/v d_{G1max}$$
 (50)

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51)

 vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max} denotes the largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 $D_{n,l,s}$ denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 D_{os} denotes the distance on the optical axis from the object up to the stop.

(Appended Mode 1-42)

The optical system according to one of appended modes 1-1 to 1-41, wherein the optical system includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn3} / D_{si} < 1$$
 (54)

where.

 D_{sn3} denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

293 D_{si} denotes a distance on the optical axis from the stop up to the image.

(Appended Mode 1-43)

An image pickup apparatus comprising:

an optical system according to one of appended modes 1-1 5 to 1-42; and

an image pickup element.

(Appended Mode 1-44)

The image pickup system comprising:

an image pickup apparatus according to appended mode $\,^{10}$

a stage which holds an object; and

an illuminating unit which illuminates the object.

(Appended Mode 1-45)

The image pickup system according to appended mode 1-44, wherein the image pickup apparatus and the stage are integrated.

(Appended Mode 2-1)

An optical system which forms an optical image on an 20 image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,

a first lens unit which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens 35 which is disposed nearest to an image, and

the following conditional expressions (16), (21), (23-1), and (24-1) are satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

$$0.6 \le L_L/D_{oi} \tag{23-1}$$

$$0.015 \le 1/v d_{min} - 1/v d_{max}$$
 (24-1)

NA denotes a numerical aperture on the object side of the 50 tive power or two single lenses, and optical system,

 D_{max} denotes a maximum distance from among distances on an optical axis of adjacent lenses in the optical system,

 ϕ_s denotes a diameter of the stop,

 L_L denotes a distance on the optical axis from an object- 55 side surface of the first object-side lens up to an image-side surface of the second image-side lens,

 D_{oi} denotes a distance on the optical axis from the object to the image.

vd_{min} denotes a smallest Abbe's number from among 60 Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the optical system. (Appended Mode 2-2)

The optical system according to appended mode 2-1, 65 wherein the following conditional expressions (35) and (36) are satisfied:

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$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{ob}/CRA_{img} \le 0.5$$
 (36)

 D_{ENP} denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical

 CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 CRA_{img} denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended mode 2-3)

The optical system according to one of appended modes 2-1 and 2-2, wherein the following conditional expression (25-1) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.65$$
 (25-1)

where.

25

D_{os} denotes a distance on the optical axis from the object up to the stop, and

 D_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 2-4)

The optical system according to one of appended modes 2-1 to 2-3, the following conditional expression (27) is satis-

$$0 \le BF/L_L \le 0.4$$
 (27)

BF denotes a distance on an optical axis from the imageside surface of the second image-side lens up to the image,

 L_{I} denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens. (Appended Mode 2-5)

The optical system according to one of appended modes (23-1) 45 2-1 to 2-4, wherein

the second lens unit includes a predetermined lens unit nearest to the image, and

the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refrac-

the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

(Appended Mode 2-6)

The optical system according to one of appended modes 2-1 to 2-5, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

the following conditional expression (40) is satisfied:

$$0.2 < R_{G1i}/D_{G1is}$$
 (40)

where.

 R_{G1i} denotes a radius of curvature of the image-side surface of the first image-side lens, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop. (Appended Mode 2-7)

The optical system according to one of appended modes 2-1 to 2-6, wherein

a conjugate image of an object is formed by the first lens unit, and

a final image of the object is formed by the second lens unit,

the following conditional expression (18) is satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C})^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) / \epsilon_d < 30$$
 (18)

where.

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on the optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image 20 point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in 25 which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens unit, and

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

(Appended Mode 2-8)

The optical system according to one of appended modes 2-1 to 2-7, wherein the following conditional expression (22) 45 is satisfied:

$$0.01 \le D_{G1max}/\phi_s \le 2.0$$
 (22)

where.

 D_{G1max} denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens

 ϕ_s denotes the diameter of the stop.

(Appended Mode 2-9)

The optical system according to one of appended modes 2-1 to 2-8, wherein the following conditional expression (26) is satisfied:

$$0.95 < \phi_{G1} / (2 \times Y / |\beta|)$$
 (26) 60

 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens,

system, and

 β denotes an imaging magnification of the optical system.

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(Appended Mode 2-10)

The optical system according to one of appended modes 2-1 to 2-9, wherein the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where.

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image,

Y denotes the maximum image height in the overall optical system.

(Appended Mode 2-11)

The optical system according to one of appended modes 2-1 to 2-10, wherein

the second lens unit includes four lenses, and

at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and

an object-side surface of the positive lens from among the positive lenses, which is positioned nearest to the object side, is a convex surface that is convex toward the object side. (Appended Mode 2-12)

The optical system according to one of appended modes 2-1 to 2-11, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image side, and

a distance of two lenses positioned on two side of the stop is fixed, and

the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

where.

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 D_{G1G2} denotes a distance on the optical axis from the image-side surface of the first image-side lens up to the object-side surface of the second object-side lens, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 2-13)

The optical system according to one of appended modes 2-1 to 2-12, wherein

the first lens unit includes a first image-side lens which disposed nearest to the image, and

the following conditional expression (31) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.5$$
 (31)

where.

 L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 L_{G2} denotes a distance on the optical axis from an objectside surface of the second object-side lens up to the image side surface of the second image-side lens.

(Appended Mode 2-14)

The optical system according to one of appended modes 2-1 to 2-13, wherein the following conditional expression (32) is satisfied:

$$0.1 < L_{G1s} / L_{sG2} < 1.5$$
 (32)

where,

 L_{GLs} denotes a distance on the optical axis from the object-Y denotes the maximum image height in the overall optical 65 side surface of the first object-side lens up to the stop, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens.

The optical system according to one of appended modes 2-1 to 2-14, wherein the following conditional expression (33) is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0$$
 (33)

where.

 $\phi_{G1\,max}$ denotes a maximum effective diameter from among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among 10 effective diameter apertures of lenses in the second lens unit. (Appended Mode 2-16)

The optical system according to one of appended modes 2-1 to 2-15, wherein

the first lens unit includes a first image-side lens which is 15 disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where.

 ${\cal D}_{os}$ denotes the distance on the optical axis from the object up to the stop, and

 ${\cal L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 2-17)

The optical system according to one of appended modes 2-1 to 2-16, wherein

the first lens unit includes the first object-side lens, and a lens which is disposed to be adjacent to the first object-side 30 lens, and

at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.

(Appended Mode 2-18)

The optical system according to one of appended modes 2-1 to 2-17, wherein the first object-side lens has a negative refractive power.

(Appended Mode 2-19)

The optical system according to one of appended modes 40 2-1 to 2-18, wherein the following conditional expression (37-1) is satisfied:

$$f_{G1}/f < -0.01$$
 (37-1)

where.

 \mathbf{f}_{Glo} denotes a focal length of the first object-side lens, and f denotes a focal length of the overall optical system.

(Appended Mode 2-20)

The optical system according to one of appended modes 2-1 to 2-19, wherein an object-side surface of the first object-side lens is concave toward the object side.

(Appended Mode 2-21)

The optical system according to one of appended modes 2-1 to 2-20, wherein the following conditional expression (38-1) is satisfied:

$$R_{G1o}/WD < -0.1$$
 (38-1)

where,

 R_{G1o} denotes a radius of curvature of the object-side surface of the first object-side lens, and

WD denotes a distance on the optical axis from the object up to the object-side side surface of the first object-side lens. (Appended Mode 2-22)

The optical system according to one of appended modes 2-1 to 2-21, wherein

an image-side surface of the second image-side lens is concave toward the image side, and

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the following conditional expression (39) is satisfied:

$$0.1 \le R_{G2i}/BF \tag{39}$$

where,

 R_{G2i} denotes a radius of curvature of the image-side surface of the second image-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 2-23)

The optical system according to appended mode 2-5, wherein

a positive lens is disposed on the object side of the predetermined lens unit, and

the positive lens is disposed to be adjacent to the predetermined lens unit.

(Appended Mode 2-24)

The optical system according to one of appended modes 2-1 to 2-23, wherein

a shape of at least one lens surface of the second image-side 20 lens is a shape having an inflection point.

(Appended Mode 2-25)

The optical system according to one of appended modes 2-1 to 2-24, wherein the following conditional expression (42) is satisfied:

$$0.01 < 1/\nu d_{G1min} - 1/\nu d_{G1max}$$
 (42)

where

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 vd_{G1min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the first lens unit, and

 vd_{G1max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the first lens unit. (Appended Mode 2-26)

The optical system according to one of appended modes 2-1 to 2-25, wherein the following conditional expression (43) is satisfied:

$$0.01 < 1/vd_{G2min} - 1/vd_{G2max}$$
 (43)

where

 vd_{G2min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and

 vd_{G2max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the second lens unit. (Appended Mode 2-27)

The optical system according to one of appended modes 2-1 to 2-26, wherein the optical system includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where,

 θ_{gF} denotes a partial dispersion ratio of the positive lens, and is expressed by θ_{gF} =(ng-nF)/(nF-nC), where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

(Appended Mode 2-28)

The optical system according to appended mode 2-27, wherein the positive lens which satisfies conditional expression (44) is included in the first lens unit. (Appended Mode 2-29)

The optical system according to one of appended mode conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s} / L_{G1s} \le 1$$
 (45)

where,

 ${\rm D}_{p1s}$ denotes a distance on the optical axis from an object-side surface of the positive lens up to the stop, and

 L_{G1s} denotes the distance on the optical axis from an object-side surface of the first object-side lens up to the stop. (Appended Mode 2-30)

The optical system according to one of appended modes 2-1 to 2-29, wherein the first lens unit has a positive refractive 5 power, and includes at least one diffractive optical element. (Appended Mode 2-31)

The optical system according to one of appended modes 2-1 to 2-30, wherein at least one diffractive optical element is disposed at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 \le D_{DLs}/D_{G1is}$$
 (48)

where.

 D_{DLs} denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 D_{G1is} denotes the distance on the optical axis from the image-side surface of the first image-side lens up to the stop. (Appended Mode 2-32)

The optical system according to one of appended modes 2-1 to 2-31, wherein at least one diffractive optical element is disposed at a position which is on the image side of the stop, and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

where.

 ${\rm D}_{sDL}$ denotes a distance on the optical axis from the stop up to the diffractive optical element, and

 ${\rm L}_{sG2}$ denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens. (Appended Mode 2-33)

The optical system according to one of appended modes 2-1 to 2-32, wherein the optical system includes a negative 35 lens which satisfies the following conditional expressions (50) and (51):

$$0.01 < 1/v d_{n1} - 1/v d_{G1max} \tag{50}$$

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51)

where,

vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max} denotes the largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 D_{n1s} denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 D_{os} denotes the distance on the optical axis from the object up to the stop.

(Appended Mode 2-34)

The optical system according to one of appended modes 2-1 to 2-33, wherein the optical system includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn3} / D_{si} < 1$$
 (54)

where

 D_{sn3} denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 D_{st} denotes a distance on the optical axis from the stop up to the image.

(Appended Mode 2-35)

The optical system according to one of appended modes 2-1 to 2-34, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

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where,

 ${\rm L}_L$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 \mathbf{D}_{ot} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 2-36)

The optical system according to one of appended modes 2-1 to 2-35, wherein

the first lens unit includes a first image-side lens which is 15 disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}L_{G1}$$
=0.39×*WD/BF*<1.8 (57)

where

 D_{os} denotes the distance on the optical axis from the object up to the stop,

 ${\cal L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 2-37)

An image pickup apparatus comprising:

an optical system according to one of appended modes 2-1 to 2-36; and

an image pickup element.

(Appended Mode 2-38)

An image pickup system comprising:

an image pickup apparatus according to appended mode 2-37;

a stage which holds an object; and

an illuminating unit which illuminates the object.

40 (Appended Mode 2-39)

The image pickup system according to appended mode 2-38, wherein the image pickup apparatus and the stage are integrated.

(Appended Mode 3-1)

An optical system comprising in order from an object side, a lens unit Gf having a positive refractive power, a stop, and

a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (9-1), and ₅₀ (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_1/\Sigma d < 0.2$$
 (9-1)

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where,

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NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

 β denotes a projection magnification of the optical system,

 d_1 denotes a distance on an optical axis from a surface positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit Gr.

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

ed denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

(Appended Mode 3-2)

The optical system according to appended mode 3-1, wherein the following conditional expression (6) is satisfied:

$$0.5 < f_{OB}/f_{TL} < 2$$
 (6)

where,

 f_{OB} denotes a focal length of the lens unit Gf, and f_{TL} denotes a focal length of the lens unit Gr.

(Appended Mode 3-3)

The optical system according to one of appended modes 3-1 and 3-2, wherein the following conditional expression ²⁰ (14) is satisfied:

$$0.7 < d_{SHOB}/d_{SHTL} < 1.3$$
 (14)

where

 d_{SHOB} denotes a distance on the optical axis from a front principal point of the lens unit Gf up to the stop, and

 d_{SHTL} denotes a distance on the optical axis from the stop up to a rear principal point of the lens unit Gr.

(Appended Mode 3-4)

The optical system according to one of appended modes 3-1 to 3-3, wherein a positive lens Lf1 is disposed nearest to an image in the lens unit Gf.

(Appended Mode 3-5)

The optical system according to one of appended modes 3-1 to 3-4, wherein the lens unit Gf includes a lens Lfe which is disposed nearest to the object, and at least one lens surface of the lens Lfe has a shape which has an inflection point. (Appended Mode 3-6)

The optical system according to one of appended modes 3-1 to 3-5, wherein the lens unit Gr includes a lens Lre which is disposed nearest to the image, and at least one lens surface of the lens Lre has a shape which has an inflection point. (Appended Mode 3-7)

The optical system according to one of appended modes 3-1 to 3-6, wherein the following conditional expressions (7-1) and (8-1) are satisfied:

$$40\% \le MTF_{OB}$$
 (7-1)

$$40\% \leq MTF_{TL} \tag{8-1}$$

where,

 MTF_{OB} denotes an MTF on an axis of the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

MTF $_{TL}$ denotes an MTF on an axis of the lens unit Gr, and 55 is an MTF with respect to a spatial frequency of fc'/4, where fc denotes a cut-off frequency with respect to the numerical

aperture on the object side of the optical system, and fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both 60 MTF $_{OB}$ and MTF $_{TL}$ are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident from a direction of the stop side, respectively.

(Appended Mode 3-8)

The optical system according to one of appended modes 65 3-1 to 3-7, wherein a positive lens Lr1 is disposed nearest to the object in the lens unit Gr.

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(Appended Mode 3-9)

The optical system according to one of appended modes 3-1 to 3-8, wherein a negative lens Lf2 is disposed on the object side of the positive lens Lf1 such that, the negative lens Lf2 is adjacent to the positive lens Lf1.

(Appended Mode 3-10)

The optical system according to one of appended modes 3-1 to 3-9, wherein a negative lens Lr2 is disposed on the image side of the positive lens Lr1 such that, the negative lens Lr2 is adjacent to the positive lens Lr1.

(Appended Mode 3-11)

The optical system according to one of appended modes 3-1 to 3-10, wherein an object-side surface of the negative lens Lf2 is concave toward the object side.

⁵ (Appended Mode 3-12)

The optical system according to one of appended modes 3-1 to 3-11, wherein an image-side surface of the negative lens Lr2 is concave toward the image side.

(Appended Mode 3-13)

The optical system according to one of appended modes 3-1 to 3-12, wherein the lens Lfe has a negative refractive power.

(Appended Mode 3-14)

The optical system according to one of appended modes 3-1 to 3-13, wherein the lens Lre has a negative refractive power.

(Appended Mode 3-15)

The optical system according to one of appended modes 3-1 to 3-14, wherein

the optical system includes at least one pair of lenses which satisfies the following conditional expressions (1), (2), and (3), and

one lens in the pair of lenses is included in the lens unit Gf, and

the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OB}/r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OB} / r_{TLj} < -0.9$$
 (2)

$$-0.1 < (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) < 0.1$$
 (3)

where,

 r_{OBf} denotes a paraxial radius of curvature of an object-side surface of the one lens in the pair of lenses,

 r_{OB_P} denotes a paraxial radius of curvature of an image-side surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 r_{TLr} denotes a paraxial radius of curvature of an image-side surface of the other lens in the pair of lenses,

 ${\rm d}_{OB}$ denotes a thickness on the optical axis of the one lens in the pair of lenses, and

 d_{TL} denotes a thickness on the optical axis of the other lens in the pair of lenses.

(Appended Mode 3-16)

The optical system according to one of appended modes 3-1 to 3-15, wherein the following conditional expression (12-1) is satisfied:

$$-10^{\circ} < \theta_{o} < 30^{\circ}$$
 (12-1)

where.

 θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object side.

(Appended Mode 3-17)

An optical instrument comprising:

an optical system according to one of appended modes 3-1 to 3-16; and

an image pickup element.

(Appended Mode 4-1)

An optical system comprising in order from an object side, a lens unit Gf having a positive refractive power,

a stop, and

a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (10-1), and (13) are satisfied:

$$0.08 < NA, 0.08 < NA'$$
 (4-1)

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_2 / \Sigma d < 2$$
 (10-1)

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the 25 optical system,

β denotes a projection magnification of the optical system, d₂ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr.

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

€d denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

(Appended Mode 4-2)

The optical system according to appended mode 4-1, wherein the following conditional expression (6) is satisfied:

$$0.5 < f_{OB} / f_{TL} < 2$$
 (6)

 f_{OB} denotes a focal length of the lens unit Gf, and

 f_{TL} denotes a focal length of the lens unit Gr.

(Appended Mode 4-3)

The optical system according to one of appended modes 4-1 and 4-2, wherein the following conditional expression 50 (14) is satisfied:

$$0.7 < d_{SHOB}/d_{SHTL} < 1.3$$
 (14)

 d_{SHOB} denotes a distance on the optical axis from the front 55 principal point of the lens unit Gf up to the stop, and

 d_{SHTL} denotes a distance on the optical axis from the stop up to the rear principal point of the lens unit Gr.

(Appended Mode 4-4)

The optical system according to one of appended modes 60 4-1 to 4-3, wherein a positive lens Lf1 is disposed nearest to an image in the lens unit Gf.

(Appended Modes 4-5)

The optical system according to one of appended modes 4-1 to 4-4, wherein the lens unit Gf includes a lens Lfe which is disposed nearest to the object, and at least one lens surface of the lens Lfe has a shape which has an inflection point.

(Appended Mode 4-6)

The optical system according to one of appended modes 4-1 to 4-5, wherein the lens unit Gr includes a lens Lre which is disposed nearest to the image, and at least one lens surface of the lens Lre has a shape which has an inflection point.

(Appended Mode 4-7)

The optical system according to one of appended modes 4-1 to 4-6, wherein the following conditional expressions (7-1) and (8-1) are satisfied:

$$40\% \le MTF_{OB}$$
 (7-1)

$$40\% \leq MTF_{TL} \tag{8-1}$$

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 MTF_{OB} denotes an MTF on an axis of the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

MTF_T denotes an MTF on an axis of the lens unit Gr, and is an MTF with respect to a spatial frequency of fc'/4, where

fc denotes a cut-off frequency with respect to the numerical aperture on the object side of the optical system, and

fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF_{OB} and MTF_{TL} are MTFs at positions at which light is focused when parallel light of an e-line is made to be incident from a direction of the stop side, respectively.

(Appended Mode 4-8)

The optical system according to one of appended modes 4-1 to 4-7, wherein a positive lens Lr1 is disposed nearest to the object in the lens unit Gr.

(Appended Mode 4-9)

The optical system according to one of appended modes 4-1 to 4-8, wherein a negative lens Lf2 is disposed on the object side of the positive lens Lf1 such that, the negative lens Lf2 is adjacent to the positive lens Lf1.

(Appended Mode 4-10)

The optical system according to one of appended modes 4-1 to 4-9, wherein a negative lens Lr2 is disposed on the image side of the positive lens Lr1 such that, the negative lens Lr2 is adjacent to the positive lens Lr1.

(Appended Mode 4-11)

The optical system according to one of appended modes 4-1 to 4-10, wherein an object-side surface of the negative lens Lf2 is concave toward the object side.

(Appended Mode 4-12)

The optical system according to one of appended modes 4-1 to 4-11, wherein an image-side surface of the negative lens Lr2 is concave toward image side.

(Appended Mode 4-13)

The optical system according to one of appended modes 4-1 to 4-12, wherein the lens Lfe has a negative refractive power.

(Appended Mode 4-14)

The optical system according to one of appended modes 4-1 to 4-13, wherein the lens Lre has a negative refractive power.

(Appended Mode 4-15)

The optical system according to one of appended modes 4-1 to 4-14, wherein

the optical system includes at least one pair of lenses which satisfies the following conditional expressions (1), (2), and (3), and

one lens in the pair of lenses is included in the lens unit Gf,

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the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OBf}/r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OBr} / r_{TLf} < -0.9$$
 (2)

$$-0.1 \le (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) \le 0.1$$
 (3)

where.

 ${\bf r}_{O\!Bf}$ denotes a paraxial radius of curvature of an object-side $^{-10}$ surface of the one lens in the pair of lenses,

 r_{OBr} denotes a paraxial radius of curvature of an image-side surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 r_{TL} denotes a paraxial radius of curvature of an image-side surface of the other lens in the pair of lenses,

 d_{OB} denotes a thickness on the optical axis of the one lens in the pair of lenses, and

in the pair of lenses.

(Appended Mode 4-16)

The optical system according to one of appended modes 4-1 to 4-15, wherein the following conditional expression (12-1) is satisfied:

$$-10^{\circ} < \theta_{o} < 30^{\circ}$$
 (12-1)

where.

 θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object 30

(Appended Mode 4-17)

An optical instrument comprising:

an optical system according to one of appended modes 4-1 to 4-16; and

an image pickup element.

(Appended Mode 5-1)

An optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to $\,^{40}$ an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and for which, a pitch of pixels is not more than 5.0 μm, comprising in order from an object side,

a first lens unit which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses,

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to the object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

a conjugate image of the object is formed by the first lens 55 unit, and

a final image of the object is formed by the second lens unit,

the following conditional expressions (16), (18), and (25) are satisfied:

$$0.08 < NA$$
 (16)

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dc} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) / \epsilon_d < 30$$

$$0.15 < D_{os}/D_{oi} < 0.8$$

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where.

NA denotes a numerical aperture on the object side of the optical system,

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G_1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of d_{TL} denotes a thickness on the optical axis of the other lens 20 the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 f_{G2C} denotes a focal length for the C-line of the second lens

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system,

 D_{os} denotes a distance on the optical axis from the object up to the stop, and

D_{oi} denotes a distance on the optical axis from the object up to the image, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

(Appended Mode 5-2)

The optical system according to appended mode 5-1, wherein the following conditional expression (24) is satisfied:

$$0.01 < 1/v d_{min} - 1/v d_{max}$$
 (24)

where,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the optical system. (Appended Mode 5-3)

The optical system according to one of appended modes 5-1 and 5-2, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where.

 L_{I} denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side surface of the second image-side lens, and

D_{ot} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5-4)

The optical system according to one of appended modes 5-1 to 5-3, wherein

the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where,

(25)

WD denotes a distance on the optical axis from the object (18) 65 up to the object-side surface of the first object-side lens, and BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the image.

(Appended Mode 5-5)

The optical system according to one of appended modes 5-1 to 5-4, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

where.

 L_L denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens,

 D_{oi} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and 15

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-6)

The optical system according to one of appended modes 5-1 to 5-5, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (31-1) is satisfied:

$$0.1 < L_{GI}/L_{G2} < 1.4$$
 (31-1) 25

where,

 L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 L_{G2} denotes a distance on the optical axis from an objectside surface of the second object-side lens up to the image side surface of the second image-side lens.

(Appended Mode 5-7)

The optical system according to one of appended modes 35 5-1 to 5-6, wherein

the first lens unit includes the first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where.

 D_{os} denotes the distance on the optical axis from the object up to the stop, and

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 5-8)

The optical system according to one of appended modes 50 5-1 to 5-7, wherein

the first lens unit includes the first image-side lens which is disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
 = 0.39×WD/BF < 1.8 (57)

where.

D_{as} denotes the distance on the optical axis from the object up to the stop,

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image.

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(Appended Mode 5-9)

The optical system according to one of appended modes 5-1 to 5-8, wherein the following conditional expression (27) is satisfied:

$$0 \le BF/L_L \le 0.4$$
 (27)

where,

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image,

 L_{I} denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 5-10)

The optical system according to one of appended modes 5-1 to 5-9, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} \le 0.5$$
 (36)

 D_{ENP} denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical

CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 CRA_{img} denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended Mode 5-11)

The optical system according to one of appended modes 5-1 to 5-10, wherein

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens,

the following conditional expression (20-1) is satisfied:

$$1.0 < 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s < 5.0$$
 (20-1)

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WD denotes the distance on an optical axis from the object up to the object-side surface of the first object-side lens,

NA denotes the numerical aperture on the object side of the optical system,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

(Appended Mode 5-12)

The optical system according to one of appended modes 5-1 to 5-11, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max} / \phi_s < 3.0$$
 (21)

where.

 \mathbf{D}_{max} denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system,

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5-13)

The optical system according to one of appended modes 5-1 to 5-12, wherein

the first lens unit includes the first object-side lens, and a lens which is disposed to be adjacent to the first object-side

at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive 5 refractive power.

(Appended Mode 5-14)

The optical system according to one of appended modes 5-1 to 5-13, wherein

the second lens unit includes a predetermined lens unit 10 nearest to the image, and

the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and

the two single lenses consist in order from the object side, 15 a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

(Appended Mode 5-15)

The optical system according to appended mode 5-14, 20

a positive lens is disposed on the object side of the predetermined lens unit, and

the positive lens is disposed to be adjacent to the predetermined lens unit.

(Appended Mode 5-16)

The optical system according to one of appended modes 5-1 to 5-15, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

the following conditional expression (40) is satisfied:

$$0.2 < R_{G1} / D_{G1is}$$
 (40) 35

where.

 $R_{\mathcal{G}1i}$ denotes a radius of curvature of the image-side surface of the first image-side lens, and

 D_{Glis} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop. (Appended Mode 5-17)

The optical system according to one of appended modes 5-1 to 5-16, wherein the optical system includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

 θ_{oF} denotes a partial dispersion ratio of the positive lens, $_{50}$ and is expressed by $\theta_{eF} = (ng-nF)/(nF-nC)$, where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

(Appended Mode 5-18)

The optical system according to appended mode 5-17, 55 wherein the positive lens which satisfies conditional expression (44) is included in the first lens unit. (Appended Mode 5-19)

The optical system according to one of appended modes 5-17 and 5-18, wherein the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s}/L_{G1s} \le 1$$
 (45)

 D_{p1s} denotes a distance on the optical axis from an objectside surface of the positive lens up to the stop, and

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 L_{G1s} denotes a distance on the optical axis from an objectside surface of the first object-side lens up to the stop. (Appended Mode 5-20)

The optical system according to one of appended modes 5-1 to 5-19, wherein the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where.

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image,

Y denotes the maximum image height in the overall optical system.

(Appended Mode 5-21)

The optical system according to one of appended modes 5-1 to 5-20, wherein the following conditional expression (22) is satisfied:

$$0.01D_{G1max}/\phi_s < 2.0$$
 (22)

where,

D_{G1max} denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens unit, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5-22)

The optical system according to one of appended modes 5-1 to 5-21, wherein the optical system satisfies the following conditional expression (26) is satisfied:

$$0.95 < \phi_{G1o}/(2 \times Y/|\beta|) \tag{26}$$

 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical system, and

 β denotes an imaging magnification of the optical system. (Appended Mode 5-23)

The optical system according to one of appended modes 5-1 to 5-22, wherein the following conditional expression (29) is satisfied:

$$-0.2 < \phi_{G1o}/R_{G1o} < 3.0$$
 (29)

 ϕ_{G1o} denotes the effective diameter of the object-side surface of the first object-side lens, and

 R_{G10} denotes a radius of curvature of the object-side surface of the first object-side lens.

(Appended Mode 5-24)

The optical system according to one of appended modes 5-1 to 5-23, wherein

the second lens unit includes four lenses, and

at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and

an object-side surface of the positive lens from among the positive lenses, which is positioned nearest to the object side, is a convex surface that is convex toward the object side. (Appended Mode 5-25)

The optical system according to one of appended modes 5-1 to 5-24, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image side, and

a distance of two lenses positioned on two side of the stop is fixed, and

the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

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where,

 ${\rm D}_{G1G2}$ denotes a distance on the optical axis from the image-side surface of the first image-side lens up to the object-side surface of the second object-side lens, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5-26)

The optical system according to one of appended modes 5-1 to 5-25, wherein the following conditional expression (32) is satisfied:

$$0.1 < L_{G1s} / L_{sG2} < 1.5$$
 (32)

where.

 ${\cal L}_{G1s}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the stop, and

 ${\cal L}_{sG2}$ denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens. (Appended Mode 5-27)

The optical system according to one of appended modes 5-1 to 5-26, wherein the following conditional expression 20 (33) is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0$$
 (33)

where.

 $\phi_{G1\,max}$ denotes the maximum effective diameter from 25 among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among effective diameter of lenses in the second lens unit.

(Appended Mode 5-28)

The optical system according to one of appended modes 30 5-1 to 5-27, wherein the first object-side lens has a positive refractive power.

(Appended Mode 5-29)

The optical system according to one of appended modes 5-1 to 5-28, wherein the following conditional expression 35 (37) is satisfied:

$$0.05 < f_{GI} / f$$
 (37)

where,

f_{G1o} denotes a focal length of the first object-side lens, and 40 f denotes a focal length of the overall optical system.
 (Appended Mode 5-30)

The optical system according to one of appended modes 5-1 to 5-29, wherein an object-side surface of the first object-side lens is convex toward the object.

(Appended Mode 5-31)

The optical system according to one of appended modes 5-1 to 5-30, wherein the optical system satisfies the following conditional expression (38) is satisfied:

$$0.02 < R_{G1} / WD$$
 (38)

where,

 R_{G1o} denotes the radius of curvature of the object-side surface of the first object-side lens, and

WD denotes the distance on the optical axis from the object 55 up to the object-side side surface of the first object-side lens. (Appended Mode 5-32)

The optical system according to one of appended modes 5-1 to 5-31, wherein

an image-side surface of the second image-side lens is 60 concave toward the image side, and

the following conditional expression (39) is satisfied:

$$0.1 \le R_{G2i} / BF \tag{39}$$

where,

 $R_{\rm G21}$ denotes a radius of curvature of the image-side surface of the second image-side lens, and

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BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-33)

The optical system according to one of appended modes 5 5-1 to 5-32, wherein the following conditional expression (41) is satisfied:

$$0.5 < f_{G1} / f_{G1} < 20$$
 (41)

where.

 \mathbf{f}_{G1o} denotes the focal length of the first object-side lens, and

 f_{G1} denotes a focal length of the first lens unit. (Appended Mode 5-34)

The optical system according to one of appended modes 5-1 to 5-33, wherein the optical system satisfies the following conditional expression (42) is satisfied:

$$0.01 < 1/vd_{G1min} - 1/vd_{G1max}$$
 (42)

where.

 vd_{G1min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the first lens unit, and

 vd_{G1max} denotes the largest Abbe's number from among Abbe's numbers for lenses forming the first lens unit. (Appended Mode 5-35)

The optical system according to one of appended modes 5-1 to 5-34, wherein the following conditional expression (43) is satisfied:

$$0.01 < 1/v d_{G2min} - 1/v d_{G2max}$$
 (43)

where,

 vd_{G2min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and vd_{G2max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the second lens unit. (Appended Mode 5-36)

The optical system according to one of appended modes 5-1 to 5-35, wherein the first lens unit has a positive refractive power, and includes at least one diffractive optical element. (Appended Mode 5-37)

The optical system according to one of appended modes 5-1 to 5-36, wherein at least one diffractive optical element is disposed at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 \le D_{DLs}/D_{G1is} \tag{48}$$

where

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 D_{DLs} denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop. (Appended Mode 5-38)

The optical system according to one of appended modes 5-1 to 5-37, wherein at least one diffractive optical element is disposed at a position which is on the image side of the stop, and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

where,

 ${\rm D}_{SDL}$ denotes a distance on the optical axis from the stop up 65 to the diffractive optical element, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens.

The optical system according to one of appended modes 5-1 to 5-38, wherein the optical system includes a negative lens which satisfies the following conditional expressions (50) and (51):

$$0.01 < 1/v d_{n1} - 1/v d_{G1max} \tag{50}$$

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51)

where,

 vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max} denotes the largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 D_{n1s} denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop.

(Appended Mode 5-40)

The optical system according to one of appended modes 5-1 to 5-39, wherein the optical system includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn3} / D_{si} < 1$$
 (54)

where

 D_{sn3} denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 D_{st} denotes a distance on the optical axis from the stop up to the image.

(Appended Mode 5-41)

The optical system according to one of appended modes 5-1 to 5-40, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_I/D_{ci} + 0.07 \times WD/BF$$
 (56)

where.

 ${\rm L_{\it L}}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 \mathbf{D}_{ot} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-42)

The optical system according to one of appended modes 5-1 to 5-41, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
=0.39×WD/BF<1.8 (57)

where,

 D_{os} denotes the distance on the optical axis from the object up to the stop,

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and 60

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-43)

An image pickup apparatus comprising:

an optical system according to one of appended modes 5-1 $\,$ 65 to 5-42; and

an image pickup element.

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(Appended Mode 5-44)

An image pickup system comprising:

an image pickup apparatus according to appended mode 5-43:

5 a stage which holds an object; and

an illuminating unit which illuminates the object.

(Appended Mode 5-45)

The image pickup system according to appended mode 5-44, wherein the image pickup apparatus and the stage are 10 integrated.

(Appended Mode 5'-2)

The optical system according to appended mode 5-1, wherein the following conditional expression (24) is satisfied:

$$0.01 \le 1/v d_{min} - 1/v d_{max}$$
 (24)

where

vd_{min} denotes the smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes the largest Abbe's number from among Abbe's numbers for lenses forming the optical system. (Appended Mode 5'-3)

The optical system according to one of appended modes 5-1 and 5'-2, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where

 L_L denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens, and

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5'-4)

The optical system according to one of appended modes 5-1, 5'-2, and 5'-3, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where,

 D_{max} denotes the maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5'-5)

The optical system according to one of appended mode 5-1, and appended modes 5'-2 to 5'-4, wherein the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

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 D_{os} denotes the distance on the optical axis from the object up to the stop, and

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5'-6)

The optical system according to one of appended mode 5-1 and appended modes from 5'-2 to 5'-5, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where,

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and

 ${\rm L}_L$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 5'-7)

The optical system according to one of appended mode 5-1, and appended modes 5'-2 to 5'-6, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} \le 0.5 \tag{36}$$

where.

 $D_{\it ENP}$ denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical system,

 ${\rm CRA}_{obj}$ denotes the maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 ${\rm CRA}_{img}$ denotes the maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended Mode 5'-8)

The optical system according to one of appended mode 5-1 and appended modes 5'-2 to 5'-7, wherein

the second lens unit includes a predetermined lens unit nearest to the image, and

the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and

the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

(Appended Mode 5'-9)

The optical system according to one of appended mode 5-1 and appended modes 5'-2 to 5'-8, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

the following conditional expression (40) is satisfied:

$$0.2 < R_{G1i}/D_{G1is}$$
 (40)

where,

 R_{G1i} denotes the radius of curvature of the image-side surface of the first image-side lens, and

 ${\rm D}_{G1is}$ denotes the distance on the optical axis from the image-side surface of the first image-side lens up to the stop. (Appended Mode 5"-2)

The optical system according to appended mode 5-1, wherein

the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where.

WD denotes the distance on an optical axis from the object up to an object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5"-3)

The optical system according to one of appended modes 5-1 and 5"-2, wherein

the first lens unit includes a negative lens, and a positive 65 lens which is disposed on the object side of the negative lens, and

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the following conditional expression (20-1) is satisfied:

$$1.0 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 5.0$$
 (20-1)

where.

WD denotes the distance on an optical axis from the object up to the object-side surface of the first object-side lens,

NA denotes the numerical aperture on the object side of the optical system,

Y_{obi} denotes the maximum object height, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5"-4)

The optical system according to one of appended modes 5-1, 5"-2, and 5"-3, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where,

 ${\rm L}_{\rm L}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens, and

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5"-5)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-4, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where,

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and

 ${\rm L}_{\it L}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 5"-6)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-5, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obf}/CRA_{img} \le 0.5$$
 (36)

where,

 ${\rm D}_{ENP}$ denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in the overall optical system.

 CRA_{obj} denotes the maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

CRA_{img} denotes the maximum angle from among angles made by a principal ray that is incident on an image plane, 55 with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle.

(Appended Mode 5"-7)

The optical system according to one of appended modes 5-1, and appended modes 5"-2 to 5"-6, wherein the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where.

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop, and

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5"-8)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-7, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (31-1) is satisfied:

$$0.1 < L_{G1} / L_{G2} < 1.4$$
 (31-1)

where,

 ${\rm L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 ${\rm L}_{\it G2}$ denotes the distance on the optical axis from an object-side surface of the second object-side lens up to the image side surface of the second image-side lens.

(Appended Mode 5"-9)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-8, wherein

the first lens unit includes the first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where.

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop, and

 ${\rm L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 5"-10)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-9, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where.

 D_{max} denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5"-11)

The optical system according to one of appended mode 45 5-1, and appended modes 5"-2 to 5"-10, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

where,

 L_L denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 D_{oi} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5"-12)

The optical system according one of appended modes 5-1, and appended modes 5"-2 to 5"-11, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
=0.39×WD/BF<1.8 (57)

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where,

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop,

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the image-(31-1) 10 side surface of the second image-side lens up to the image.

As described heretofore, the present invention is suitable for an optical system in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably, and an optical instrument in which such optical system is used. Moreover, the present invention is suitable for an optical system in which, an aberration is corrected favorably, and while having a high resolution because of the favorable correction of aberration, the overall length of the optical system is short, and for an image pickup apparatus and an image pickup system in which such optical system is used.

What is claimed is:

1. An optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and for which, a pitch of pixels is not more than 5.0 μm , comprising in order from an object side,

a first lens unit which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

a conjugate image of the object is formed by the first lens unit, and

a final image of the object is formed by the second lens unit, and

the following conditional expressions (16), (18), and (25) are satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C})^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) \epsilon_d < 30$$

$$(18)$$

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

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NA denotes a numerical aperture on the object side of the optical system,

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a

case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be 5 the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens unit,

- ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side 10 of the optical system,
- ${\rm D}_{os}$ denotes a distance on the optical axis from the object up to the stop, and
- ${\rm D}_{oi}$ denotes a distance on the optical axis from the object up to the image, and
- the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.
- 2. The optical system according to claim 1, wherein the following conditional expression (24) is satisfied:

$$0.01 < 1/v d_{min} - 1/v d_{max}$$
 (24)

where,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, $_{25}$ and

 vd_{max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the optical system.

3. The optical system according to claim $\hat{\mathbf{2}}$, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where,

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m L}_{L}$ denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an imageside surface of the second image-side lens, and

 ${\cal D}_{oi}$ denotes the distance on the optical axis from the object up to the image.

4. The optical system according to claim **3**, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where,

 ${
m D}_{max}$ denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes a diameter of the stop.

5. The optical system according to claim 1, wherein the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where,

WD denotes a distance on an optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the optical image.

6. The optical system according to claim 5, wherein

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative 60 lens, and

the following conditional expression (20-1) is satisfied:

$$1.0 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj}) / \phi_s \le 5.0$$
 (20-1)

where,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens,

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NA denotes the numerical aperture on the object side of the optical system,

Yobj denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

7. The optical system according to claim 6, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where,

L_L denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens, and

 D_{oi} denotes the distance on the optical axis from the object up to the image.

8. The optical system according to claim **1**, wherein the following conditional expression (24) is satisfied:

$$0.01 < 1/v d_{min} - 1/v d_{max}$$
 (24)

where.

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vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the optical system.

9. The optical system according to claim $\hat{\mathbf{8}}$, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where,

L_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens, and

 D_{oi} denotes the distance on the optical axis from the object up to the image.

10. The optical system according to claim 9, wherein the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the optical image.

11. The optical system according to claim 10, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

where

L_L denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens,

 D_{oi} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the optical image.

12. An image pickup apparatus comprising: an optical system according to claim 1; and an image pickup element.

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- 13. An image pickup system comprising: an image pickup apparatus according to claim 12; a stage which holds an object; and
- an illuminating unit which illuminates the object.
- **14**. The image pickup system according to claim **13**, 5 wherein the image pickup apparatus and the stage are integrated.
- **15**. The optical system according to claim **1**, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where.

- L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an imageside surface of the second image-side lens, and
- ${\rm D}_{oi}$ denotes the distance on the optical axis from the object up to the image.
- **16**. The optical system according to claim **1**, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where,

- ${
 m D}_{max}$ denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and
- ϕ_s denotes a diameter of the stop.
- 17. The optical system according to claim 1, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where,

- BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the optical image, and
- L_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens.
- **18**. The optical system according to claim 1, wherein the following conditional expressions (35) and (36) are satisfied: 40

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{ob}/CRA_{img} < 0.5$$
 (36) 45

where.

- D_{ENP} denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,
- Y denotes a maximum image height in an overall optical 50 system,
- CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and
- CRA_{img} denotes a maximum angle from among angles 55 made by a principal ray that is incident on an image plane, with the optical axis, and
- an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle.
- 19. The optical system according to claim 1, wherein
- the second lens unit includes a predetermined lens unit nearest to the image, and
- the predetermined lens unit has a negative refractive power 65 as a whole, and consists a single lens having a negative refractive power or two single lenses, and

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- the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.
- 20. The optical system according to claim 1, wherein the first lens unit includes a first image-side lens which is disposed nearest to the image, and
- an image-side surface of the first image-side lens is concave toward the image side, and
- the following conditional expression (40) is satisfied:

$$0.2 < R_{G1i}/D_{G1is}$$
 (40)

where,

- $R_{G_{II}}$ denotes a radius of curvature of the image-side surface of the first image-side lens, and
- D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop.
- 21. The optical system according to claim 1, wherein
- the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

the following conditional expression (20-1) is satisfied:

$$1.0 \le 2 \times (WD \times \tan(\sin^{-1}NA) + Y_{obj})/\phi_s \le 5.0$$
 (20-1)

where.

- WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens,
- NA denotes the numerical aperture on the object side of the optical system,
- Yobj denotes a maximum object height, and
- ϕ_s denotes a diameter of the stop.
- 22. The optical system according to claim 5, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where

- L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an imageside surface of the second image-side lens, and
- D_{oi} denotes the distance on the optical axis from the object up to the image.
- 23. The optical system according to claim 5, wherein the following conditional expression (27) is satisfied:

$$0 \le BF/L_L \le 0.4$$
 (27)

where.

- BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the optical image, and
- L_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens.
- **24**. The optical system according to claim **5**, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{ob}/CRA_{ing} < 0.5 \tag{36}$$

where

- D_{ENP} denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,
- Y denotes a maximum image height in an overall optical system,
- CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

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- ${
 m CRA}_{img}$ denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and
- an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a 5 direction of counterclockwise rotation is let to be a positive angle.
- 25. The optical system according to claim 1, wherein the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the second lens unit includes a second object-side lens which is disposed nearest to the object, and

the following conditional expression (31-1) is satisfied:

$$0.1 \le L_{G1}/L_{G2} \le 1.4$$
 (31-1)

where.

- L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to an imageside surface of the first image-side lens, and
- L_{G2} denotes a distance on the optical axis from an objectside surface of the second object-side lens up to the image side surface of the second image-side lens.
- 26. The optical system according to claim 1, wherein the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where.

- ${\rm D}_{os}$ denotes the distance on the optical axis from the object up to the stop, and
- ${\cal L}_{G1}$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.
- **27**. The optical system according to claim **5**, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where.

- ${\rm D}_{max}$ denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and
- ϕ_s denotes a diameter of the stop.
- **28**. The optical system according to claim **1**, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

where.

- L_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens,
- \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image,
- WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and
- BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the optical image.
- 29. The optical system according to claim 1, wherein the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{\alpha\beta}/L_{G1} = 0.39 \times WD/BF < 1.8$$
 (57)

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where.

- ${\rm D}_{os}$ denotes the distance on the optical axis from the object up to the stop,
- L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the first image side lens,
- WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and
- BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the optical image.
- 30. The optical system according to claim 1, wherein
- the first lens unit includes the first object-side lens, and a lens which is disposed to be adjacent to the first objectside lens, and
- at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.
- **31**. The optical system according to claim **5**, wherein the second lens unit includes a predetermined lens unit nearest to the image, and
- the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and
- the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.
- **32.** The optical system according to claim 1, wherein the optical system includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where,

- θ_{gF} denotes a partial dispersion ratio of the positive lens, and is expressed by θ_{gF} =(ng-nF)/(nF-nC), where
- nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.
- 33. The optical system according to claim 32, wherein the positive lens which satisfies conditional expression (44) is included in the first lens unit.
- **34**. The optical system according to claim **32**, wherein the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s}/L_{G1s} \le 1$$
 (45)

where,

- ${\rm D}_{p.l.s}$ denotes a distance on the optical axis from the objectside surface of the positive lens up to the stop, and
- L_{G1s} denotes a distance on the optical axis from an object-side surface of the first object-side lens up to the stop.
- **35**. The optical system according to one of claim **1**, wherein the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where.

- BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the optical image, and
- Y denotes a maximum image height in the overall optical system.

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